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ENGINEERING:

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VOL. CXII.—No. 2910.] *LONDON: FRIDAY, OCTOBER 7, 1921.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See Advertisement page 87, Sept. 30.

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Naval Outfits a Speciality.
4078

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designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
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See their Illus. Advertisement, page 107, last week.

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Birkenhead.
See Illustrated Advertisement Page 100, Jan. 28.

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Steam and Electric Cranes,
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See Advertisement page 63. 9091

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All communications to—
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General Secretary.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS,
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Yarrow Patent Water-tube Boilers.
9564
Messrs. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
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See Full Page Advt., page 76, Sept. 16.

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HALESOWEN. 7116

Head, Wrightson & Co.,
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See Advertisement page 66. 2402

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9196
About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices.
TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM.
See Full Page Advertisement page 74, Sept. 16

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CHARTERED PATENT AGENTS,
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"Spencer-Hopwood" Patent Boilers. *See page 22*
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29, Southampton Buildings, London, W.C. 2.

S. Sokal, CHARTERED PATENT AGENT.
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T.N. 4515 Museum. 9675

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9727
See half-page Advertisement, page 74, Sept. 30.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

Chief Engineer: C. B. STROMEYER, M.I.C.E.

Founded 1854 by Sir William Fairbairn.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 9310

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of South Milwaukee, Wisconsin, U.S.A., and formerly represented in the British Isles by Messrs. G. F. West & Co., wish to announce that they have now Opened their Own Office at

19, IDDESLEIGH HOUSE, CAXTON STREET, WESTMINSTER,

and henceforth All Communications for them should be so addressed.

9741

The Institution of Mechanical Engineers,

Storey's Gate, Westminster, S.W.1.

ELEVENTH REPORT to the ALLOYS RESEARCH COMMITTEE on some Alloys of Aluminium, by Walter Rosenhain, B.A., D.Sc., F.R.S., Sydney L. Archbutt, F.I.C., and D. Hanson, D.Sc. (256 pp., 24 Plates, 92 Figs. in Letterpress. Price £2 2s. 0d.)

This Report will be discussed at the General Meetings, on 21st and 28th October, at Six p.m. S 189

University of Manchester.

EVENING CLASSES in Civil and Mechanical Engineering. These classes will meet on MONDAYS, at Seven and Eight p.m. respectively. First Lecture, October 10th. Fee 10s. 6d. each class. For further particulars, apply to the Internal Registrar.

S. CHAFFERS, Bursar. S 174

University of London.

KING'S COLLEGE.

SPECIAL ADVANCED ENGINEERING LECTURES.

The following Special Advanced Lectures have been arranged for post-graduate and other advanced Students:—

First Term.

1. "Liquid Fuels." (A Course of Five Lectures.) By Harold Moore, M.Sc. Tech. F.C.S., M.Inst. Pat. Tech. Alternate Mondays at 5.30 p.m.; commencing October 17th, 1921.
2. "Liquid Fuel Engines." (A Course of Five Lectures.) By W. R. Ormandy, D.Sc., F.C.S., M.I. Auto. E. Alternate Mondays at 5.30 p.m.; commencing October 24th, 1921.
3. "Bridge Construction." (A Course of Five Lectures.) By H. W. FitzSimons, B.Sc., A.M.Inst.C.E. Alternate Thursdays at 5.30. p.m.; commencing October 13th, 1921.
4. "Cascade Induction and Synchronous Motors and Generators." (A Course of Five Lectures.) By L. J. Hunt, M.Inst.C.E., M.I.E.E. Tuesdays at 5.30 p.m.; commencing October 18th, 1921.

S. T. SHOVELTON, M.A., Secretary.

S 210

Correspondence Courses for B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.). Assoc.M.Inst.C.E., M.R.S.I., etc., 8–10, Trafford Chambers, 58, South John Street, Liverpool. 9296

Inst. C.E., I. Mech. E., B.Sc., and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., M.E.H., A.M.Inst.C.E., F.S.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Thousands of successes during the last sixteen years. Courses may commence at any time.—39, Victoria St., Westminster, S.W. Tel. 4780 Victoria. 9449

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TENDERS.

COUNTY BOROUGH OF WALLASEY.

SEACOMBE FERRY IMPROVEMENTS.

The Corporation of Wallasey invite

Tenders for the Carrying Out

of that portion of the above Work, denominated work "B" NEW FLOATING ROADWAY, and Work "C" CUT FOR NEW FLOATING ROADWAY, and works in connection therewith, in accordance with the detailed Plans and Specification of Messrs. Wilton & Bell, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool, at whose office copies of the Specification and Drawings may be seen.

Contractors desiring to obtain copies of Plans and Specification and Schedule of Quantities, may do so on payment of a fee of £2 2s. for each work, or of £3 3s. for the two Works, which fees will not be returnable.

Tenders on the Form of Tender provided must be delivered to the undersigned in a sealed envelope endorsed "Tender for Seacombe Ferry Improvements, Works B and/or C," not later than Twelve Noon, Saturday, November 5th, 1921.

GEO. LIVSEY, Town Clerk.

Town Hall, Wallasey.
7th October, 1921. S 247

LONDON COUNTY COUNCIL.

Tenders are Invited for the

PROVISION and ERECTION of an ELECTRIC GOODS LIFT, capable of dealing with a load of 30 cwt. at the Stamford Hill Stores Depot, Portland Avenue, N. 16.

The Specification, Bills of Quantities, Form of Tender, etc., may be obtained from Mr. G. W. Humphreys, C.B.E., the Chief Engineer of the Council, at the County Hall, Spring Gardens, S.W., after payment to the Cashier of the Council of £1. This amount will be returnable only if the tenderer shall have sent in a *bona-fide* Tender, and shall not have withdrawn the same.

The contract documents may be inspected before the payment of the fee.

No Tender received after Four p.m. on Monday, the 24th October, 1921, will be considered. The Council does not bind itself to accept any Tender.

JAMES BIRD, S 226
Clerk of the London County Council.

EAST INDIAN RAILWAY.

The East Indian Railway Company is prepared to receive

Tenders for the Supply and

DELIVERY of:—

INSULATED CABLES, &c., as per Specifications to be seen at the Company's Offices.

Tenders are to be sent to the undersigned, marked "Tender for Insulated Cables," not later than Eleven o'clock a.m., on Wednesday, the 19th day of October instant.

The Company reserves to itself the right to divide the order, also to decline any Tender without assigning a reason, and does not bind itself to accept the lowest or any Tender.

For each specification a fee of £1 1s. is charged, which cannot under any circumstances be returned.

By Order,
G. E. LILLIE, Secretary.

Nicholas Lane, London, E.C. 4.
4th October, 1921. S 243

EDINBURGH CORPORATION ELECTRICITY SUPPLY.

PORTOBELLO STATION.

The LORD PROVOST, MAGISTRATES and COUNCIL invite

Tenders for the Following

WORK:—

Specification No. 39.

ELECTRIC AND STEAM DRIVEN FEED PUMPS.

A copy of the Specification can be obtained from the office of Sir Alexander Kennedy, 17, Victoria Street, Westminster, S.W. 1, on or after the 7th October.

Tenders on the prescribed form enclosed in sealed envelopes and addressed on the outside "Electricity Supply." Tenders to Specification No. 39, must be delivered at the office of the undersigned not later than 18th October, 1921, at Ten a.m.

The Council do not bind themselves to accept the lowest or any Tender.

A. GRIERSON, S.S.C., Town Clerk.

City Chambers,
Edinburgh.
4th October, 1921. S 245

TO ENGINEERS AND OTHERS.

The METROPOLITAN ASYLUMS BOARD invite

Tenders for the Installation of

TWO NEW INDEPENDENT DRY BACK MULTITUBULAR BOILERS and Incidental Work at the Children's Infirmary, Cleveland Street, London, W. 1, in accordance with Drawings and Specification prepared by Mr. T. Cooper, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Drawings, Specification and Form of Tender may be inspected at the Office of the Board, Embankment, E.C. 4, on and after Ten a.m., on Monday, 10th October, 1921, and Drawings, Specification and Form of Tender can then be obtained upon payment of a deposit of £1 in respect of the work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions of the Form of Tender and after the Specification and Drawings have been returned.

Tenders, addressed as noted on the Form of Tender, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, 26th October, 1921.

(By Order), S 260
DUNCOMBE MANN,
Clerk to the Board.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:

No.		Specification Fees.
1.	Steel Work for Bridges	10s. 0d.
2.	Steel Tyres for Carriages and Wagons	10s. 0d.
3.	India Rubber Hosepipes, Sheets, &c.	7s. 6d.
4.	Sheffield Tools, &c.	5s. 0d.
5.	Carriage Door Handles, Hinges, &c.	7s. 6d.
6.	Bolts, Nuts, Rivets, &c.	10s. 0d.
7.	Station Bells, Bibcocks, &c.	5s. 0d.
8.	Mild Steel Bars, Sections, &c., for miscellaneous purposes ...	10s. 0d.
9.	Stationery, &c.	10s. 0d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Work for Bridges," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 18th October, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.
Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 5th October, 1921. S 259

UXBRIDGE JOINT HOSPITAL BOARD.

The Board Require Immediate

DELIVERY on Acceptance of Tender of a NEW VERTICAL STEAM BOILER, 2 ft. 9 in. in diameter, 7 ft. 6 in. high, working pressure 60 per square inch, with fittings complete. Two sets of water gauges, steam gauge, safety valve and steam valve for outlet, check valve for feed inlet and blow-off cock. To be fitted up to the disinfector at the Hospital, Kingston Lane, Uxbridge, Middlesex.

Tenders for boiler and fittings to reach me not later than first post 15th October, 1921.

CHARLES WOODBRIDGE, Clerk.

38, High Street,
Uxbridge. S 265

THE BENGAL AND NORTH WESTERN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply and

DELIVERY of:—

(A) MATERIALS for the Construction of 30 Bogie Carriages.
(B) 120 PAIRS of WHEELS and AXLES.
(C) 240 AXLE BOXES.

as per Specifications to be seen at the Company's Offices.

Tenders, addressed to the undersigned and marked "Tender for Bogie Carriages" or as the case may be, are to be lodged not later than noon on Monday the 24th day of October, 1921.

For Specification (A) a fee of £1; and (B) and (C) a fee of 10s. will be charged which cannot, under any circumstances, be returned.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
E. A. NEVILLE, Managing Director.

237, Gresham House,
Old Broad Street, London, E.C.
5th October, 1921. S 272

CALCUTTA ELECTRIC SUPPLY CORPORATION, LTD.

The Directors of the Calcutta E.S. Co., invite

Tenders for the following

PLANT to be delivered and erected at their Generating Station at Cossipore, Calcutta:—

Specification No. 70. One 15,000 Kw. TURBO-ALTERNATOR and CONDENSING PLANT.

Specification No. 71. Two Water-tube BOILERS with an Evaporation of 60,000 lbs. per hour each.

The above Specifications can be seen at and obtained from the Offices of the Consulting Engineers, Messrs. Kennedy & Donkin, 17, Victoria Street, London, S.W. 1, on and after Wednesday next the 12th instant. Tenders are to be sent in by November 9th, 1921.

IVOR C. THOMAS, Secretary.

3 & 4, Clements Inn,
Strand, W.C. 2.
5th October, 1921. S 262

EDINBURGH CORPORATION ELECTRICITY SUPPLY.

The LORD PROVOST, MAGISTRATES and COUNCIL invite

Tenders for the Following

WORK:—

Specification No. 38.—FOUR 10–15 Tons HAND OPERATED OVERHEAD TRAVELLING CRANES.

A copy of the Specification and Drawings can be obtained from the office of Sir Alexander Kennedy, 17, Victoria Street, Westminster, S.W. 1, on or after the 7th October. An additional copy of the Specification can be obtained if required.

Tenders on the prescribed Form, enclosed in sealed envelopes and addressed on the outside "Electricity Supply Tender to Specification No. 38," must be delivered at the office of the undersigned not later than 18th October, 1921, at Ten a.m.

The Council do not bind themselves to accept the lowest or any Tender.

A. GRIERSON, S.S.C., Town Clerk.

City Chambers,
Edinburgh.
4th October, 1921. S 244

APPOINTMENTS OPEN.

RESEARCH DEPARTMENT, ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF METALLURGICAL RESEARCH.

Required, Temporary HEAD of BRANCH for not less than one year.

Candidates should possess good academic qualifications and have specialised in non-ferreous and physical metallurgy.

Initial salary £600 and bonus (total emoluments at present approximately £963).

Applications in writing with copies of testimonials, and reference to any published work should be made to the CHIEF SUPERINTENDENT, Research Department, Royal Arsenal, Woolwich, S.E., from whom the Conditions of Employment may be obtained. S 154

STAFFORDSHIRE EDUCATION COMMITTEE.

COUNTY TECHNICAL COLLEGE, WEDNESBURY.

Applications are Invited for

the POST of ASSISTANT LECTURER IN METALLURGY at the above College. The candidate should have had good works and teaching experience, and a University degree is desirable.

Salary according to the Burnham scale.

Further particulars and forms of application, which should be returned on or before 13th October, 1921, may be obtained from the undersigned on receipt of a stamped addressed envelope.

GRAHAM BALFOUR, Director of Education.

County Education Offices,
Stafford.
September, 1921. S 195

COUNTY BOROUGH OF CROYDON.

EDUCATION COMMITTEE.

Wanted Immediately,

TEACHER of MACHINE CONSTRUCTION. Wednesday Evening, 7.30 to 9.30. State full particulars of education, training, age and experience to—

THE PRINCIPAL,
Central Polytechnic, Croydon. S 258

SALFORD EDUCATION COMMITTEE.

ROYAL TECHNICAL COLLEGE.

Principal:—B. PRENTICE, D.Sc., Ph.D.

Lecturer in Physics, Graduate

of a British University — REQUIRED Immediately. Particulars and forms of application may be obtained from the undersigned.

R. MARTIN, Secretary.

Education Office,
Salford. S 239

LONDON COUNTY COUNCIL.

Required, at the L.C.C.

SHOREDITCH TECHNICAL INSTITUTE, PITFIELD STREET, N. 1, a VISITING TEACHER of Elementary Engineering and Ordinary Metal-Work, for two attendances a week. Fee 15s. an attendance, subject to revision in consequence of the Burnham Award and meanwhile to a temporary addition of 20 per cent. conditionally.

Preference given to candidates who have served or attempted to serve with H.M. Forces. Apply Education Officer (T. 1a), New County Hall, S.E. 1 (stamped addressed foolscap envelope necessary), for Form of particulars, to be returned by 11th October, 1921. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
S 207

PORTSMOUTH MUNICIPAL COLLEGE.

MECHANICAL AND CIVIL ENGINEERING DEPARTMENT.

Principal:
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THE ROTARY PIERCING MACHINE FOR STEEL AND COPPER BILLETS.

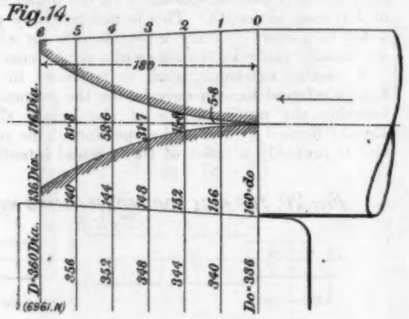
By C. E. Davies. A.M.I.Mech.E.

(*Continued from page* 430.)

(6) *The Dependance of the Formation of the Hole on the Angle of Twist.*—We may now study more closely the action, at entry, of the leading end of the billet between the rolls. The rolls are so adjusted in relation to one another that the solid billet, 160 mm. diameter, is gradually rolled thinner to the smallest diameter, 136 mm., and thus brought to $0 \cdot 85\, d_0$. Assuming further that the taper of the side of the conical portion of the rolls is 1 : 15, a conical billet 180 mm. long is obtained, which can be dissected into six equal parts (see Fig. 14).

For each section the angle of twist in degrees is calculated, from the dimensions given in Fig. 14.

Fig. 14.



Taking $\beta = 5$ deg. and $\tan \alpha = 1/15$, the second factor (equation (8)), becomes 19,640, and for the first section, $\phi_1 = 9 \cdot 24$ deg., similarly for each succeeding section . . . $\phi_6 = 370 \cdot 50$ deg.

The values of ϕ for each section from 1 to 6 are as follows:

$\phi_1 = 9 \cdot 24°$
$\phi_2 = 37 \cdot 54°$
$\phi_3 = 86 \cdot 14°$
$\phi_4 = 157 \cdot 00°$
$\phi_5 = 251 \cdot 46°$
$\phi_6 = 370 \cdot 50°$

These angles are in Fig. 15 plotted as ordinates, and the resulting curve shows clearly the rapid increase of the torsion angle. From this follows a tendency to form a hollow of rapidly-increasing intensity. At first the curve rises very slowly from 0 to 1, and the beginning of hole formation can actually only be noticed at point 1.

The formation of a hole, through the twisting of the sections would scarcely be obvious, moreover the power available would be insufficient, and it seems probable that a twisting of the material takes place at the outer skin (to the calculated extent) and that the inner portion follows the outer in distortion; thus the interior material by reason of its cohesion, is drawn towards the outside.

Fig. 16 shows the fibre displacement during a pass of a square bar in the ordinary rolling process, which has been proved as a result of exhaustive experiments (fully reported in a paper by E. Blass, *Stahl und Eisen*, 1882, July; pages 283 to 293; 1883, February, pages 121 and 122).

If these theories are applied to the inclined roll

Fig. 15.
TORSION ANGLE.

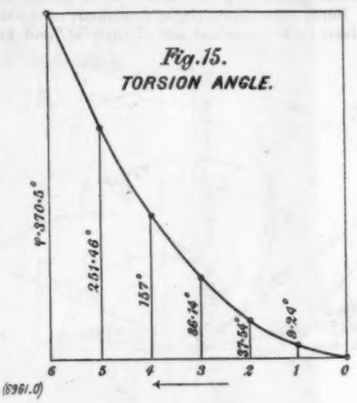


DIAGRAM SHOWING ACTION OF ORDINARY ROLLS.

Fig. 16.

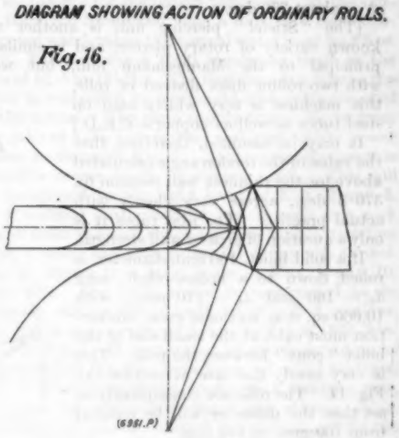
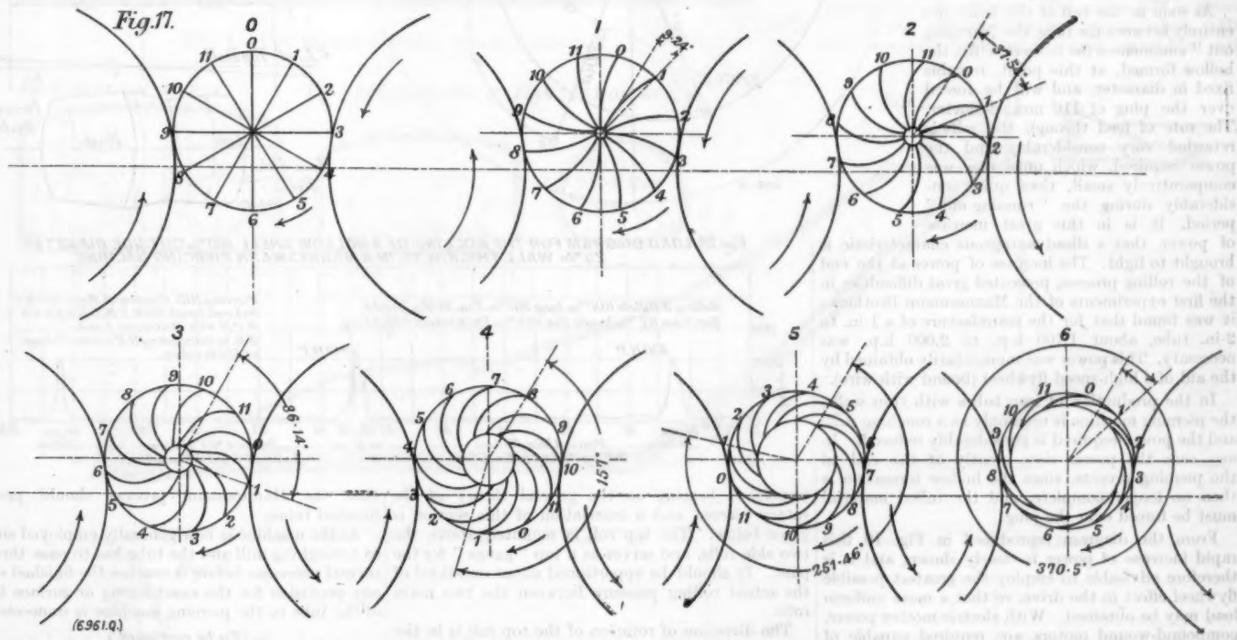


Fig. 17.



Referring to this figure: At section 0.—The billet is held fast between the rolls, and each radial line is straight. At section 1.—A distortion of the outer fibres has already taken place. $\phi_1 = 9 \cdot 24$ deg., the radial lines are correspondingly bent, and at the centre of the billet a hollow is gradually formed (since it is assumed that the radial lines cannot be stretched).

With this angular distortion there is a simultaneous displacement of the fibres in the direction of the length of the billet, so that the radial lines are curved not only in the plane of the section, but are also distorted in a spiral form away from this plane. As the successive sections from 3 to 6 are considered, the radial lines are seen to approach continually the outer circumference, in correspondence with the rate of increase of the angle of twist.

Unfortunately, time has not so far allowed experiments to give positive proof of this fibre structure; these, however, can be carried out, as they were previously on the normal rolling process (referred to in the paper mentioned above). In the meantime, it is fairly safe to assume that the formation of the hole in the rolled material may be explained in this way.

In Fig. 18, on page 496, the progressive bending of one radial line is shown, as it runs through, from section 0 to 6, and it will be found that the inner ends of the radii lie on a spiral curve; the value of the angle of twist at each individual section is given, with the corresponding radius of the inside of the hole formed. From this an empirical formula can

Table II.

Section No.	Torsion Angle, Degrees.	$\frac{d_i}{d_o}$	d_o mm.	d_i mm.
1	9·24	0·037	156	5·8
2	37·54	0·104	152	15·8
3	86·14	0·214	148	31·7
4	157·00	0·372	144	53·6
5	251·46	0·584	140	81·8
6	370·50	0·85	136	116·0

be deduced for calculating the interior diameter d_i, from the outer diameter d_a,

$$d_i = \frac{d_a}{100}\sqrt{\phi + 0{\cdot}05\,\phi^2} \quad . \quad . \quad (18)$$

With the aid of Fig. 18 and equation (18), Table II, page 495, is calculated. In Fig. 14 the values from the above table are shown, and the shape of the hollow so formed may be taken as a true representation of the actual result in practice.

Attention may here be called to the fact that the "Stiefel" piercing mill, in which thin-walled copper tubes may be rolled, by reason of its design works almost entirely with an angle of twist ϕ = about 300 deg.

[The "Stiefel" piercing mill is another well-known variety of rotary piercer, and is similar in principal to the Mannesmann mill, but works with two rolling discs instead of rolls, this machine is very widely used on steel tubes as well as copper.—C.E.D.]

It may be assumed, therefore, that the value of the torsion angle calculated above for the thinnest wall (section 6), 370·5 deg., agrees very closely with actual practice. For iron tubes it is only a question of greater wall strength.

If a solid billet, 160 mm. diameter, is rolled down to a hollow shell, with d_a = 160 and d_i = 110 mm., with 10,600 sq. mm. sectional area, this section must exist at the small end of the billet "cone" between the rolls. This is very nearly the case at section (5), Fig. 14. The rolls are consequently so set that the diameter will be reduced from 160 mm. to 140 mm.

As soon as the end of the billet lies entirely between the rolls, the "running out" commences (as in section (6)), the hollow formed, at this point, remains fixed in diameter, and will be forced over the plug of 110 mm. diameter. The rate of feed through the rolls is retarded very considerably and the power required, which until now was comparatively small, rises quite considerably during the "running-out" period. It is in this great increase of power that a disadvantageous characteristic is brought to light. The increase of power at the end of the rolling process, presented great difficulties in the first experiments of the Mannesmann Brothers; it was found that for the manufacture of a 1-in. to 2-in. tube, about 1,700 h.p. to 2,000 h.p. was necessary. This power was momentarily obtained by the aid of a high-speed flywheel (bound with wire).

In the production of iron tubes with thin walls, the piercing machine is used only as a roughing mill, and the power required is considerably reduced. In any case the power rises greatly at the end of the piercing process, since the hollow formation is then no longer complete, and the rolled material must be forced over the plug.

From the diagram reproduced in Fig. 19 this rapid increase of power is clearly shown, and it is therefore advisable to employ the greatest possible flywheel effect in the drive, so that a more uniform load may be obtained. With electric motive power, compound-wound motors are required capable of 150 per cent. momentary overload. The actual rolling operation (as shown by diagram) is completed in about 20 seconds, and the remaining 16 seconds is occupied in bringing the flywheel, which has been retarded, in the giving up of power, back to its normal speed.

A 360-h.p. motor, with the above-mentioned overload capacity, in conjunction with a flywheel of 30 tons at 150 r.p.m., is sufficient for the reduction of billets up to 160 mm. outside diameter, down to a wall thickness of 25 mm. to 30 mm. (The billet being 600 mm. long.)

The motor with the flywheel is retarded from 150 r.p.m. to 128 r.p.m., after 20 seconds, and is, after a further 16 seconds, restored to its original speed, in this way the voltage during the rolling period can be kept almost constant. Large mills are to-day installed with 2,000 h.p. motors, and flywheels of 40 tons to 50 tons at about 100 r.p.m.

Following the matters above dealt with, the succeeding sections in the original German article deal almost entirely with the mechanical details of the Mannesmann piercer. It is not proposed to include this matter in the present paper, which is intended, more particularly, to explain the general theory of the rotary piercer than the actual detail design.

Moreover, the design described does not differ materially from that adopted in British-made machines of this type; and in some respects modern practice, both British and foreign, shows some modification, to the typical design detailed. A general description, with illustrations and drawing, of an example of British construction for a similar machine will be given at the end of this article.

Some remarks on the arrangement of the top roll, given in the original are of interest, and have an important bearing on the general theory of the rotary piercer, and a translation of this section is given below. The top roll is mounted above the two side rolls, and serves as a top "gauge" for the pass. It should be apportioned about one-third of the actual rolling pressure between the two main rolls.

Fig. 18.

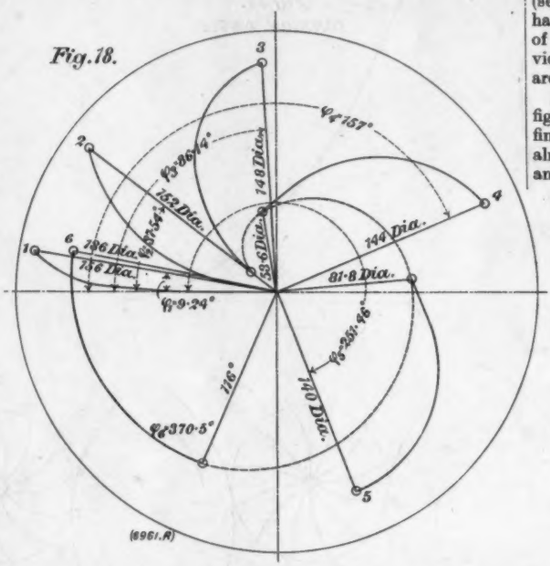


Fig. 20. TOP ROLL FOR 360 H.P. PIERCING MILL.

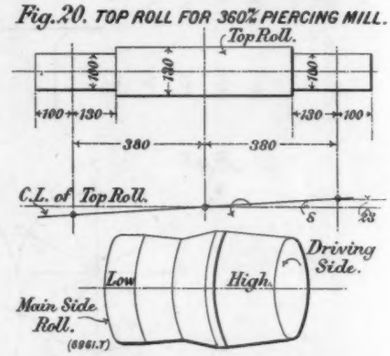
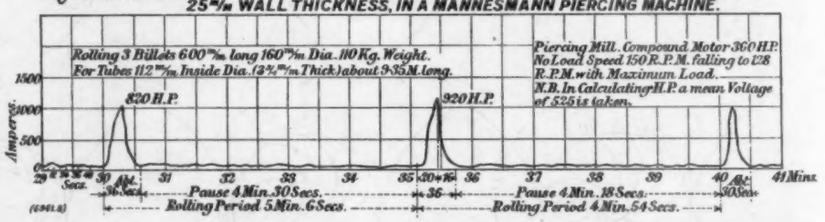


Fig. 19. LOAD DIAGRAM FOR THE ROLLING OF A HOLLOW SHELL 160 m/m OUTSIDE DIAMETER, 25 m/m WALL THICKNESS, IN A MANNESMANN PIERCING MACHINE.


Rolling 3 Billets 600 m/m long 160 m/m Dia. 110 Kg. Weight.
For Tubes 112 m/m Inside Dia. (3¾ m/m Thick) about 9·35 M. long.
Piercing Mill. Compound Motor 360 H.P.
No Load Speed 150 R.P.M. falling to 128 R.P.M. with Maximum Load.
N.B. In Calculating H.P. a mean Voltage of 525 is taken.
820 H.P.
920 H.P.
1500
1000
500
Ampers
Pause 4 Min. 30 Secs.
Pause 4 Min. 18 Secs.
Rolling Period 5 Min. 6 Secs.
Rolling Period 4 Min. 54 Secs.
41 Mins.
(8961.S)

The direction of rotation of the top roll is in the same sense as that of the main rolls. The centre line of the top roll lies in the horizontal plane, 145 mm. to 185 mm. above the centre point "M" of the machine, and it is placed at such an angle that the movement of its circumference is adapted to the screw motion of the hollow billet; Fig. 20 gives dimensions of this roll and shows the angle which its centre line makes with that of the machine.

From this figure,

$$\text{Tan } \delta_1 = 23/380 = 0{\cdot}0606, \text{ or } \delta_1 = 3{\cdot}5°.$$

Since "S x" (the axial advance of the billet per revolution), can be reduced empirically to about half of the theoretical value), according to the friction existing between the rolls and work, and the resistance of the piercing plug; the inclination of the top roll is fixed to agree with this reduced rate of travel.

Then is, also, the inclination of the top roll in relation to that of the main rolls, so arranged that there is sufficient clearance between the rolls and bearings. [This last point will be appreciated by all designers of Mannesmann type piercers, as it is always difficult to obtain room for a satisfactory design of the bearings, when the three rolls are set closely together, for dealing with the minimum billet diameter.—C.E.D.]

The translation of the article published in *Stahl und Eisen* is here concluded.

It should be noted that in Fig. 20, the top roll is shown to be parallel, whereas it is general practice to make this roll conical in form, the angle of the cone being equal to that of the main rolls. It is rather difficult to see that a parallel roll would give satisfactory results, but as previously mentioned, in some particulars the design illustrated does not represent the latest practice; especially in regard to the roll form. In Figs. 4, 5 and 6 (see page 397 *ante*) the main rolls are shown to have a nearly parallel extension on the outlet side, of 160 mm. in length. This is not generally provided in modern piercing mills, the rolls for which are usually made in the shape of a double cone.

A parallel extension, such as is shown in the figures referred to, can only be for the purpose of finishing the outer surface of the hollow shell, already formed by the conical portion of the rolls, and is probably a relict of the original intention, that the Mannesmann process should produce finished tubes.

As the machine is now generally employed simply as a roughing mill and the tube has to pass through several processes before it reaches the finished state, any provision for the exact sizing or surface finish of the tube in the piercing machine is unnecessary.

(To be continued.)

Institution of Naval Architects.—The Council of the Institution have awarded two post-graduate research scholarships in naval architecture of the value of 250*l.* per annum each, given by the Royal Commissioners of the 1851 Exhibition, as follows: Mr. H. W. Nicholls, of the Royal Naval College, Greenwich, who will carry out research on the vibration of ships. Mr. W. R. Andrew, of Liverpool University, who will investigate the behaviour of ships at sea during a long-distance voyage, and report upon shipbuilding and conditions abroad.

Adhesion Locomotive for the Harz Railway.—On the line Halberstadt-Blankenburg, in the Harz mountains, sections of gradients exceeding 40 : 1,000 have so far been worked on the rack system. The firm of A. Borsig, of Berlin-Tegel, has recently introduced an adhesion locomotive, driven by superheated steam, which is said to give complete satisfaction on gradients of 60 : 1,000 maximum. On these gradients the locomotive can manage trains of 200 tons and, by keeping the sand-box going, even of 260 tons, and it is intended to try the engine on gradients of 80 : 1,000.

THE HERLANDSFOSSEN HYDRO-ELECTRIC PLANT.

THE Herlandsfossen power plant is one of Norway's most recently completed hydro-electric installations. Although, in comparison with several modern plants, both in Europe and in America, it is comparatively speaking, small, yet it possesses several unique features which give it an interest of its own. One of the chief of these is the manner in which the water is conveyed from the service reservoir to the turbines. This is effected by an unlined pressure tunnel the static head of which at its lower end is 450 ft. This is, we believe, by far the highest head for which an unlined tunnel has been attempted in Europe, if not in the world. From the foot of this tunnel the pipe lines run through an horizontal tunnel to the power house. In this way the scenery has not been disfigured by pipe lines running down the hillside. The power produced is used mainly for lighting and for general purposes in the neighbouring towns and villages, while a portion is taken by the Norske Saltverker, which concern manufactures salt from sea water by evaporation. The station may also be coupled when desired in parallel with the stations supplying the City of Bergen, for the purpose of carrying abnormal peak loads.

The fall of Herlandsfossen is situated on the Osterøen in the Province of Söndre Bergenhus. In the year 1916, the concession for the falls was bought by the Commune of Hosanger, which together with the Communes of Haus and Hamre at once commenced the development of the falls for power purposes. The river, above the intake for the power station, has a catchment area of about 62·5 sq. km. (24 sq. miles) and provides, with the exceptionally high rainfall which prevails in this district, a continuous available output of about 7,000 h.p. to 8,000-h.p., the gross head varying between 130·5 m. and 139·5 m. (428 ft. and 457 ft.). The Lake of Storevand, which has an area of 7 sq. km. (2·7 sq. miles), provides exceptional storage facilities, as about 47 per cent. of the total run-off from the catchment area may be stored here. For this reason, the power station has been built with a maximum capacity of 14,000-h.p., so that, running in parallel with other stations, it is able to provide the power necessary for the peak load. A view of the exterior of the power station is given in Fig. 1, annexed, while the illustrations, Figs. 2 to 6 annexed, give a general idea of the scheme together with sections of intake, &c.

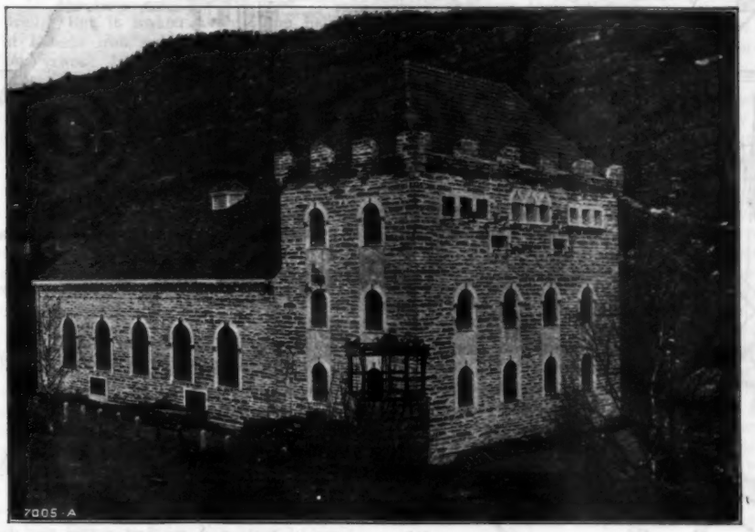
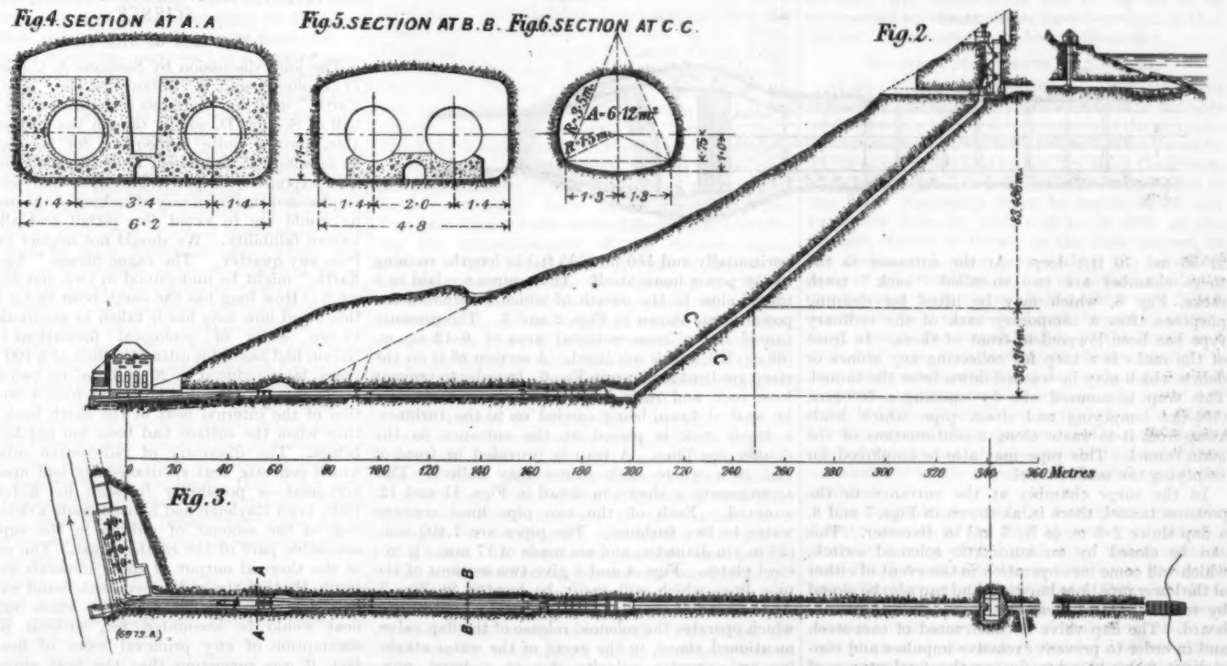


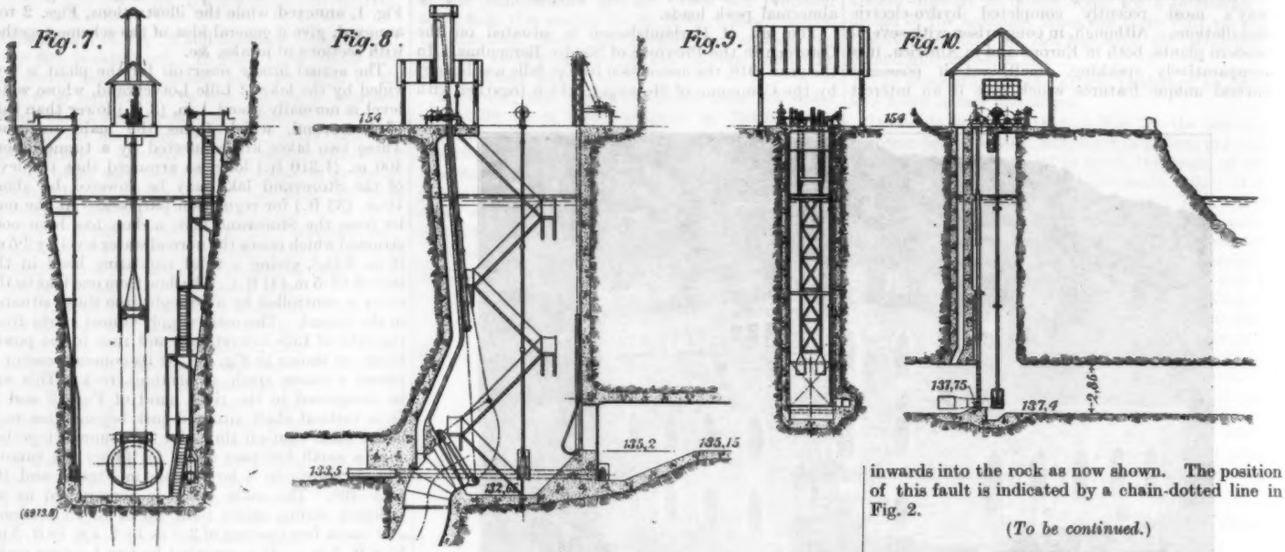
FIG. 1. THE HERLANDSFOSSEN POWER STATION.

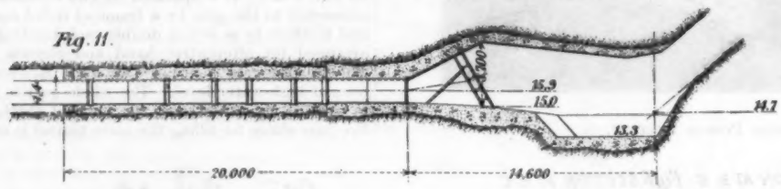
The actual intake reservoir for the plant is provided by the lake of Lille Lötvetvand, whose water level is normally about 1 m. (3 ft.) lower than that of Storevand, which forms the main reservoir. These two lakes are connected by a tunnel about 400 m. (1,310 ft.) long, so arranged that the level of the Storevand lake may be lowered by about 10 m. (33 ft.) for regulation purposes. At the outlet from the Storevand lake, a dam has been constructed which raises the normal water level by 2·5 m. (8 ft. 3 in.), giving a total regulating head in the lake of 12·5 m. (41 ft.). The flow from one lake to the other is controlled by a wrought-iron sluice situated in the tunnel. The main supply tunnel starts from the lake of Lille Lötvetvand and runs to the power house, as shown in Fig. 2. At its commencement is placed a coarse trash, or strainer, rack. This will be recognised to the right hand of Figs. 2 and 3. In a vertical shaft situated just beyond this rack is the main shut-off sluice for this tunnel, together with a small bye-pass sluice for filling the tunnel. This is shown to a large scale in Figs. 9 and 10, page 498. The main sluice is constructed as an ordinary sliding sluice built up of rolled sections, and has a free opening of 2·5 m. by 2·5 m. (8 ft. 3 in. by 8 ft. 3 in.). It is operated by two hoisting racks connected to the gate by a frame of rolled sections, and is lifted by a 50-ton double rack hoisting gear, arranged for alternative hand and electric drive. The hoisting gear is situated about 13 ft. above the normal high-water level. The whole gear is placed in a small building over the vertical shaft. The bye-pass sluice for filling the main tunnel is of cast-iron and has a free opening of 0·5 m. by 0·5 m. (19½ in. by 19½ in.). It is operated from the same building by a 2½-ton screw-hoisting gear. The whole of the lake of Lille Lötvetvand with the coarse trash-rack and sluices may be unwatered by closing the main sluice in the tunnel joining the two lakes and running the water off through a sluice in a small dam closing the natural outlet from the lake.

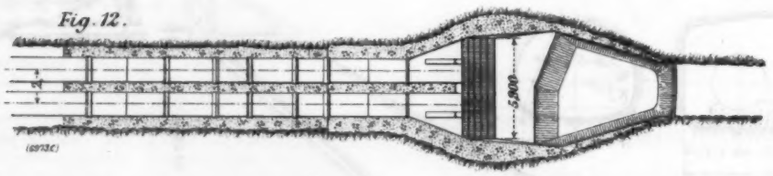
The main tunnel from the intake to the main sluice has a sectional area of 7·5 sq. m. (81 sq. ft.), and is 1,400 m. (4,600 ft.) long, with an average gradient of 1 : 500. This tunnel ends in the surge chamber shown in Figs. 7 and 8, which measures 6·5 m. by 6·5 m. (21 ft. 6 in. by 21 ft. 6 in.) at the base, and is



THE HERLANDSFOSSEN HYDRO-ELECTRIC PLANT; SURGE CHAMBER AND SLUICES.







21·35 m. (70 ft.) deep. At the entrance to the surge chamber are two so-called "sack" trash racks, Fig. 8, which may be lifted for cleaning purposes after a temporary rack of the ordinary type has been lowered in front of them. In front of the racks is a trap for collecting any stones or debris which may be washed down from the tunnel. This trap is scoured out by opening a 500-mm. (19½-in.) emptying and drain pipe which leads away from it to waste along a continuation of the main tunnel. This pipe may also be employed for emptying the main tunnel.

In the surge chamber at the entrance to the pressure tunnel, there is, as shown in Figs. 7 and 8, a flap sluice 2·5 m. (8 ft. 3 in.) in diameter. This can be closed by an automatic solenoid switch, which will come into operation in the event of either of the lower pipe lines bursting, and can also be closed by remote control from the power station switchboard. The flap valve is constructed of cast-steel, and in order to prevent excessive impulses and consequent water-hammer during the final stages of closing, it is provided with a self-acting water brake. The lifting and release mechanism for this valve is placed in a building over the surge chamber from the floor level of which a permanent iron stairway leads down to the bottom of the chamber. From the back of the flap sluice an air vent 0·55 m. by 0·9 m. (21½ in. by 35½ in.) leads up to the top of the surge chamber; and for filling the pipes and pressure tunnel a 250-mm. (10-in.) bye-pass pipe, fitted with a gate valve is provided.

The water is carried from the surge chamber through about 200 m. (656 ft.) of unlined pressure tunnel to the level of the power-house. This tunnel subsequently gives place to two pipes, laid almost horizontally and 180 m. (595 ft.) in length, running to the power-house itself. These pipes are laid in a tunnel close to the mouth of which is situated the power-house shown in Figs. 2 and 3. The pressure tunnel has a cross-sectional area of 6·12 sq. m. (66 sq. ft.), and is not lined. A section of it on the steep gradient is shown in Fig. 6. In order to prevent loose rock, and other débris which may occasionally be washed down, being carried on to the turbines, a trash rack is placed at the entrance to the double pipe lines. A trap is provided in front of this rack where such stones may collect. This arrangement is shown in detail in Figs. 11 and 12, annexed. Each of the two pipe lines conveys water to two turbines. The pipes are 1,400 mm. (55 in.) in diameter, and are made of 17 mm. (⅝ in.) steel plates. Figs. 4 and 5 give two sections of the pipe lines which will easily be located in Fig. 3. At the head of the pipe line is placed a control disc which operates the solenoid release of the flap valve, mentioned above, in the event of the water attaining an excessive velocity due to a burst pipe, &c. Air valves and manholes are also provided at this point. The pipe lines are fitted with sliding expansion joints where necessary, and arrangements are made for installing butterfly valves at the outlet of the pressure tunnel at a later date.

It was originally intended that the unlined pressure tunnel should be carried to a point about 130 m. (425 ft.) nearer to the power-station than has actually been done; in fact, down to the enlargement shown in the excavation along the horizontal length in Fig. 2. During the pressure tests of the tunnel, however, the rock showed an unexpected fissure or fault overhead, and the pipe lines had to be extended inwards into the rock as now shown. The position of this fault is indicated by a chain-dotted line in Fig. 2.

(To be continued.)

THE BRITISH ASSOCIATION.

(Continued from page 470.)

In concluding our comments upon the transactions of Section A we first notice the discussion on the Age of the Earth.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

The Age of the Earth.

The joint discussion by Sections A, C (Geology), D (Zoology), and K (Botany) of the "Age of the Earth," drew an enormous audience to the lecture hall of Section D, which, though the largest available, proved quite inadequate for the occasion. In opening the discussion, Lord Rayleigh remarked that exponents of particular views had too much emphasised their own way of looking at the problem; he would try to avoid this pitfall and allow for human fallibility. We should not neglect evidence from any quarter. The vague phrase "Age of the Earth," might be understood in two, not identical, ways: How long has the earth been fit for habitation? and how long has it taken to accumulate the known series of geological formations? Lord Kelvin had based his estimates (first of a 100 million years, later reduced to 20 millions) on two lines of arguments. In the first he argued from a consideration of the internal heat of the earth back to the time when the surface had been too hot for living beings. The discovery of radioactive substances which generate heat spontaneously had upset that argument—a possibility foreseen by Kelvin. In 1906, Lord Rayleigh had himself made a determination of the amount of radium in the superficial accessible part of the earth's crust. The estimate of the thermal output of those minerals gave the result that, if the radium-content found extended to a depth of some 20 miles, the whole output of heat would be accounted for, without Kelvin's assumption of any primeval store of heat. In fact, it was surprising that the heat output was not greater than found; the earth seemed to generate more heat than it radiated into space.

Kelvin secondly attempted to set a limit of time to the sun's heat. For this heat he could find no other adequate source than secular contraction, and that would only account for an age of 20 million years, which geologists rejected as too small. We did not at present know definitely of any source of stellar heat. Yet some red giant stars were radiating heat at 1,000 times the rate of the sun, and they should hence have expended an appreciable fraction of their total energy in historic times, according to the contraction theory. Nobody would maintain that this had occurred, and we

had to look for some other explanation. Kelvin's arguments would not stand in the light of our present knowledge. Modern knowledge of radio-activity, on the other hand, seemed to supply a basis for an estimate. Uranium disintegrated into a lead of atomic weight 206, thorium into a lead of mass 208, whilst ordinary lead had a mass of 207·1. A gramme of uranium gave $1{\cdot}88 \times 10^{-11}$ gramme. of helium and $1{\cdot}22 \times 10^{-10}$ gramme of lead per annum. All our helium seemed to be of radio-active origin, but it leaked away; the helium found in Eocene iron only indicated an age of 30 million years. If all the lead were due to uranium, we obtained an age of 925 million years when judging from the broggerite found in the pre-Cambrian rocks of Moss (Norway). Taking all the lead accumulated on the earth crust, H. N. Russell estimated the age—too high probably—at 11×10^9 years; another estimate of Russell's yielded 8×10^9 years. The latter smaller figure was about six times the age indicated by the oldest radioactive minerals examined. The upshot was that the various radioactive methods indicated a small multiple of 1,000 million years (probably 6,000,000,000 years) as the period during which the earth's crust had been fit for the habitation of living beings.

Professor W. J. Sollas, F.R.S., of Oxford, said that geologists would gladly shift the responsibility for the time scale to others. Referring to the study of pleochroic halos by Joly, he stated that specks of radioactive minerals in the biotite of granitic rocks were found to be surrounded by dark rings (up to seven), ascribed to the bombardment of the rock by particles; the outermost rings would be due to the swiftest particles from RaC, the inner rings to slower particles. In the case of thorium minerals also the ring diameters agreed exactly with the calculations, and thus confirmed the age estimates of Rayleigh and Holmes. In the case of uranium minerals, however, the two inner rings were one-sixth too large, suggesting to Professor Joly that when the rings began to form, *i.e.*, in Caledonian times, the particles had a greater range than at present. Lord Rayleigh had briefly referred to this. Thus the radium clock need not have kept uniform time. The late R. Barrell had attempted to adjust estimates based upon the rate of the denudation of rocks and the formation of sediments (the last was first tried by Haughton), which might change in the course of ages. Thus, if one foot of sediment had been deposited in the sea in 375 years in Pleistocene times, it might have taken 3,700 years in lower Palæozoic ages. There were also gaps and discontinuities in stratified series. On the other hand, the estimates based upon the rate at which rivers supplied sodium to the sea were in agreement with the conclusions drawn from stratification. The only reliable estimates were those of Baron de Geer, who counted the annual layers deposited by the melting ice-sheet in its retreat. He found a length of 12,000 years for the post-glacial period in Scandinavia, whilst former estimates from the post-glacial deltas in Switzerland were several thousand years in excess of that. If Kelvin had restricted geologists, they were now treated more than generously; they did not greatly care, but, said Professor Sollas, they could not at present be expected to commit themselves to reconstructing their science.

Professor A. S. Eddington, speaking next, remarked that the peculiar variations of the Cepheid variables suggested another source of energy besides gravitational contraction. These variations, ranging in period from 5 to 40 days, were quite different from the fluctuations of ordinary variables which were ascribed to periodical mutual eclipsing. In the Cepheids the periods were far too short; the eclipsing body would have to be inside the star. The light pulsations seemed intrinsic in the stars, and were probably caused by an alternation of contractions and expansions. If the stars contracted appreciably in the course of time, their periods would not remain constant. To account for the radiation of these stars, their density should increase by 1 per cent. in 40 years; but δ Cephei, observed since 1785, changed only at the rate of 1 per cent. in 58,000 years; that is, at a much slower rate than that required by the contraction theory. Thus, Kelvin's time scale should be lengthened five hundredfold, at least during that state of evolution.

Professor J. W. Gregory, F.R.S., of Glasgow, dealt in his contribution (which Professor Jehu read in his absence) chiefly with the salinity of the sea. The chlorine might come from salt and from volcanoes; the age estimates varied between 70 and 150 millions (chlorine giving a longer age than sodium, according to Holmes). Geologists were ready to multiply their estimates by 10 or 20 to satisfy physicists. The biologists present at the meeting did not rise to continue the discussion.

Seismological Investigations.

The twenty-sixth report of this committee (chairman Professor H. H. Turner, secretary Mr. J. J. Shaw) deplores the death of its active member, Professor John Perry, and mentions minor troubles in the new offices at Oxford. The 100*l.* grant from the Caird fund of the British Association continues; the further grant so far given by the Association had to be discontinued, but the Government has allowed 300*l.* Milne-Shaw machines have been sent to Bombay, Cairo, Wellington, Hong Kong and Rio de Janeiro. As regards the breaking of submarine cables, which Milne was inclined to ascribe to submarine earthquakes, the evidence collected during the past year is not confirmatory; in some cases the seismograph traces were almost maliciously quiet in such times, but the cable companies did not wish details published for business reasons. So far then submarine shocks, if responsible, did not seem to affect seismological records. A few explosions of the past year, of which notice had been given, also failed to affect the curves; the great powder explosion near Petrograd, early in the war, was not recorded by Galitzin's delicate instruments either, whilst the sound waves were recorded. With respect to the great earthquake of December 16, 1920, the report gives some terrible detail based mainly upon the reports of Father Gherzi and Mr. E. G. Mann. The earthquake took place in Kansu, China, longitude about 105·5 deg. E. and latitude 35·5 deg. N. The official Chinese estimates of the loss of life was one million; a foreign estimate of 100,000 victims was characterised as "conservative." The Eskdalemuir instrument was out of equipment at the time; the American records spoke of a probable distance of only 3,000 miles, and the first British estimates were hence erroneous. But Professor Turner dwelt on the difficulties of identifying the commencement of the decisive wave-periods in this connection. At Oxford Mr. W. H. Robinson happened to be observing the level-error of the transit circle on December 16, and was astonished to see the reflected image of the wires move slowly away through 4 seconds of arc and keep oscillating in this manner for half an hour. Rapid telegraphic communication of seismological observations was obviously needed.

With respect to microseisms, the slight, almost incessant earth tremors, Mr. Shaw had only negative results to report. Last year he had been able to identify these slight disturbances at two stations 2 miles apart. Last winter he arranged, near West Bromwich, three stations, at the corners of a triangle, the north-south side having a length of 10·6 miles. In this larger distance the tremors became unindentifiable; the maxima being no longer in accord. The discontinuity may be due to geological faults. Mr. Shaw also mentioned that when the sun shone on the south wall of his house the effect on the seismograph in the basement was as if the bottom of the basement had sunk a little.

Tides.

The report of the committee "To Assist Work on the Tides" (chairman Professor H. Lamb, secretary Dr. A. T. Doodson; Professor J. Proudman and others) was presented by Professor H. H. Turner, who drew attention to this valuable document, which was drawn up by Dr. Doodson, of the Tidal Institute, University of Liverpool. The Astronomer Royal subsequently commented upon the extraordinarily, good work done. The five main conclusions, restricted to short-period tides, were: (1) On the basis of previous methods of harmonic analysis and prediction, the errors of prediction for certain British stations may amount to more than a foot, apart from errors due to the use of predicting machines: (2) Half of this error may be due to the inadequate treatment of shallow-water effects: (3) The remaining half of the error is due to tidal constituents, which are not included in the schedules of Sir. G. H. Darwin, 1883, and whose origin is not definitely known [this was a very important point, Professor Turner remarked]: (4) While the methods of analysis and prediction are restricted as heretofore to the consideration of the 1883 constituents, there can be no material improvements in either analysis or predictions [this latter conclusion is a direct consequence of (3)]: (5) The time devoted to the modification of harmonic "constants" by repeated analyses would probably be better spent in analysing for new constituents. The report deals in its three parts with procedure and results, with methods (referring to Professor Proudman's report of 1920 for a critical review of these methods), and with the behaviour of predicting machines.

As regards the accuracy of tide-predicting machines, tests were made in collaboration with the hydrographical department, and Mr. Selby at the National Physical Laboratory, using the Newlyn calculations together with the Roberts machine (R) and the India Office machine (N), each having unknown errors. Measurements of heights were conducted every four hours on 19 days, at intervals of 10 days. The results indicated that both the machines (especially the R) have zero errors; that both have serious time errors averaging six minutes; that the throw of the machines (apparent range of tide) is deficient, but not seriously so, and that the machines have not produced predictions with the accuracy required in research work. The two machines agreed better with one another than with the calculations. As they were built by the same maker, that might be expected, but so far only five constituents out of the 20 or 30 represented on the machines have been used, so that the test ought perhaps to be supplemented.

Internal Movements in the Sea.

At the Edinburgh meeting of 1892 Dr. Otto Pettersson, of Stockholm, had described the methods used in Sweden for the determination of the temperature and salinity of the sea water and of sea currents. At the meeting just held his son, Dr. Hans Pettersson, of Göteborg, gave an account of recent progress in this field. Soundings down to depths of 30 and 40 metres were, he said, now made daily at the research station of Bornö, on the Gullmarfjord, in the Baltic, and they proved that the boundary surfaces or transition layers of different salinity (fresh water from rivers, Baltic water and North Sea water) were maintained with surprising persistency, though the actual heights of the layers and their slope (near the coast) might change greatly. A boundary surface might in a day or two rise or fall by 20 m., and hundreds of millions of tons of one water layer were carried out to the sea and replaced by other layers. These changes could be more rapidly studied by the aid of densimeters than by chemical analyses which required the collection of the samples.

The chain-areometer of Dr. Pettersson's gave the density correct to the fifth decimal. In this instrument a very slender gold chain was suspended from the bottom of a quartz-float so as partly to lie on the bottom of a graduated cylinder in which the float rises. A model of this instrument was shown; it is mounted in gimbals and used on light-ships and research vessels. The recording float likewise used was a copper vessel, of half a cubic metre capacity, suspended over a pulley, a bicycle wheel mounted on a bridge. The curves drawn by the barograph pen of this instrument agreed with the records of the daily hydrographic soundings, but the instrument could only be used on steep shores in the absence of ice. A siphon instrument had therefore been devised which was very efficient, though not recording. The siphon tube communicated by a long lead tube with the deep water and by another lead tube with the surface water; the U glass tube of the siphon contained diluted alcohol and, below this, coloured kerosene which would neither freeze nor sink under the sea water. Current meters, suspended from buoys, gave curves of the direction and velo-

city of the water movements every half-hour, the driving clock work allowing of taking 700 photographic records. Gas analyses were also conducted.

The main cause of the currents, Dr. Pettersson stated, might be tidal. He had found a high coefficient of correlation between the wind component parallel to the coast and the vertical displacements of the layers, but no correlation between the boundary movements and the barometer. A wind from the sea would drive water up the fjord increasing the static pressure in the inner bay; 24 hours later the boundary might be depressed by 30 and more times the amount of the level rise. These currents were of great importance for the fisheries.

Sections taken across the Baltic in various direction showed that the southern waters were covered by a uniform layer of 40 or 50 m. thickness of low salinity (7 per cent.); the deeper basins below that contained water of higher salinity which sustained flat fish and cod. When these layers became in the course of time depleted of oxygen, the fish could no longer live and they emigrated, as had been proved, until an inflow of sea water (from the North Sea through the Sound and the Belts) replenished the oxgyen. How this inflow took place Dr. Pettersson illustrated by a model, a tank made up of two stout glass plates and a block of wood cut so as to represent the bottom of the Baltic, the height scale being exaggerated. Waters of five different colours indicated horizontal layers of different salinities and densities. When fresh water was introduced in the tank surface on the one side, the surface layer deepened and spread slowly; when a salt solution was introduced on the other side, also from the top—imitating inflow through the shallow Belts—the heavy salt water sank down the slopes replacing the lighter water in some of the bottom valleys. With the shallow water currents the shoals of herrings entered the Baltic, and the water later enabled the deep-water fish to live. In past centuries, Dr. Pettersson suggested, the inflow of sea water seemed to have been more regular and stronger; the surface layer of fresh or brackish water was then thinner, and the whole Baltic was more like a fjord and less like an inland sea. It was also more exposed to freezing, a state of affairs of which there was historical evidence in the fourteenth and fifteenth centuries. Such freezing, very rare now, need not indicate climatic changes.

Meteorology and Cosmical Physics.

The deliberations of the department for meteorology and cosmical physics, which sat on two mornings, simultaneously with the main Section A, were strengthened both by a meeting of the Meteorological Society, held at Edinburgh on the first day of the Association week, and by the establishment of a branch of the Meteorological Office, Air Ministry, in the home of the section, the National Philosophy department of the university. Mr. A. Giblett and Lieutenant D. Sinclair were in charge of a radiotelegraphic station which had especially been erected on the roof of the building, and large synoptic charts were displayed every day and were corrected as fresh reports arrived. Many other interesting photographs and diagrams were also exhibited. On the other hand an International Conference, held in London in the second week in September, kept many meteorologists away from Edinburgh.

Cyclones and Anti-Cyclones. The Drought.

Dr. Harold Jeffreys' paper on "The Cause of Cyclones" was an analysis of the thermal and dynamic theories of the origin of cyclones, none of which he found satisfactory. The most common theory, that cyclones were due to local heating and ascending air columns, modified by the rotation of the earth, might account for stationary cyclonic movements, even on the huge scale of the monsoons, but it could not explain the travelling cyclones of the temperate zones, and still less the tropical cyclones, disturbances having diameters of 1,000 km. Captain C. K. M. Douglas contributed some "Remarks on the Theory of Cyclones and Anti-cyclones," by Professor V. Bjerknes, of Christiania, discussing the theory with respect to the condition of the upper air and, particularly the unsymmetrical distribution of temperature and wind in the upper air round a large cyclone, as it developed and finally became a dying system. Cold air, he said, met warm air somewhere in the temperate zone in a wavering line, the warm air tending to rise above the cold. A new cyclone was an area of tropical air partly shut off by Polar air, the forward or steering edge of this warm air mass rising steeply to great heights, as shown by the cirrus clouds. Mr. W. H. Dines, F.R.S., dealt with the Discontinuity of Temperature at the Top of the Troposphere, that is to say, the lower layer of the atmosphere, about 11 km. in height, in which the temperature—apart from local inversions—decreases gradually, whilst in the stratosphere (or isothermal layer) above the troposphere the temperature remains fairly constant. This discontinuity is one of the outstanding difficulties in the radiation theory of the stratosphere. Mr. Dines ascribed the discontinuity to the very gradual sinking and spreading out, in higher latitudes, of air which had entered the stratosphere in tropical regions, the process being similar to the formation of temperature inversions at lower levels by descending air currents in anti-cyclones.

In his paper on the Dry Period of 1921 in England and Wales, Mr. M. de Carle Salter compared the drought of this year with the periods of the dry years of 1887, 1893 and 1911, giving details of the deficiency of rainfall from February to July inclusive, both of absolute and partial drought, as defined by Symons, and of the geographical distribution of the rainfall in relation to the normal. Members could see that the drought had been less severe in Scotland than in the southern Midlands, where it was most remarkable.

The Geophysical Observatory in the Shetlands.

Dr. Crichton Mitchell described the observatory near Lerwick, which has developed out of a radiotelegraphic station erected by the Admiralty during the war. Last year the Air Ministry converted the station into a geophysical observatory placed in charge of the Meteorological Office, especially for the purpose of investigating the radiotelegraphic disturbances accompanying auroral displays. From observations taken with a base line of 25 km., the average height of aurorae is estimated at 95 km.

The Magnetic Storms of the Present Solar Cycle.

This paper by the Rev. A. L. Cortie, S.J., of Stonyhurst, was a further observational statistical contribution to the study of solar and magnetic phenomena, on which he has presented papers to Section A for the last twenty-five years, with the particular object of throwing light upon the mode of the transmission of particles from the sun to the earth. His comparative tables of sun spots, bright prominences, H_α absorption markings, and calcium flocculi covered the period 1913 to June, 1921, and were based on the records from the observatories at Stonyhurst, Tortosa and Kodaikanal. The spots attained their maximum in 1917. The bright prominences had their maximum profile area in 1915 and 1917, and the bright Ca flocculi and the dark H_α absorption markings their maximum areas in 1920. Magnetic disturbances are distinguished as g. or v.g. (great or very great), according as the range exceeds the main daily range of the five quietest days by 15 minutes or 20 minutes of arc. The conclusions drawn are (1) that the general magnetic activity in this solar cycle (1913 to 1921) appears to coincide with the mean daily area of the Ca and H_α; (2) consistently with past solar cycles the magnetic phenomena increase in activity as the sun spots and flocculi decrease in mean latitude after the sun spot maximum has been attained, disturbed areas of the sun being most effective probably when situated near the heliographic latitude of the earth; (3) the four magnetic storms of great violence of the present cycle were (*a*) 1917, August 9, 10, and renewed August 13, 14; (*b*) 1919, August 11, 12; (*c*) 1920, March 22, 23; (*d*) 1921, May 12 to 21. In cases (*a*), (*c*) and (*d*) the storm coincided with the passages of very great sun spots. These cases support the view that the action of a sun spot area is by the projection of a set of divergent rays proceeding fanwise from the area and probably diffused into a cloud belt. Some of the series of storms occurred when the sun spot was far removed from the central meridian. In case (*b*) the magnetic storm of August, 11, 12, 1919, the sun spot, the largest group of the year, a triple equatorial group extending 20 deg. in longitude, did not appear on the east limb of the sun until August 14. If magnetic storms were connected with disturbed sun spot areas, the Rev. A. L. Cortie remarked, in accordance with a great mass of evidence, this case was decisive against a radial discharge of electric particles from the area, but was not inconsistent with the hypothesis of a wide diffusion of electric particles by mutual repulsion in the form of a belt of clouds round the sun. Many of the observations to which Father Cortie drew attention supported these views which have more and more forced themselves upon him. He pointed out, for instance, that the magnetic disturbances might be greatest when the sun spot was hidden by faculae, so that it was necessary to follow the life history of the spot.

The Microchronograph at the Royal Observatory, Edinburgh.

The Microchronograph, which the Astronomer Royal for Scotland, Professor R. A. Sampson, F.R.S., described, is in use at the Royal Observatory, Edinburgh, for registering clock times of any signal, accurately within 0·001 sec., for the purpose of examining short-period changes in the relative rates of two clocks, or the lag of a controlled clock or of one part of an apparatus with respect to another. The importance of securing such high accuracy had much increased, the Astronomer Royal, Sir Frank Dyson, subsequently remarked, since observatories were being supplied with radiotime signals. The comparsion by the aid of pendulums, Professor Sampson pointed out in introducing his paper, had its difficulties, and he had found an adaptation of the oscillograph most suitable for the purposes mentioned, because the oscillograph recorded the growth and progress of an electric signal without introducing any obnoxious lag, the lag being the same for all disturbances. The apparatus is illustrated in our Figs. 11 to 14, page 501. Fig. 11 is a view of the whole, somewhat bulky, apparatus; Fig. 12 a plan of the arrangement; and Figs. 13 and 14 give details of the construction of the oscillograph detector. Fig. 15 is a diagram exemplifying the results obtained.

The detector D is placed between the poles of a powerful electro-magnet M, a peculiar but powerful instrument constructed about 1870. Between the pole pieces of 5 in. square a field of 12,000 gauss per square centimetre had been measured in the gap of 2 mm. width. A mirror carried by the detector sends to the camera C (with cylindrical lens *c*) the reflected beam of light which comes from the lantern A through the slit S and the lens L. The signal (clock or other) given by an electric current of a few milliamperes is photographically recorded on a moving film by the minute rotation of the mirror. The film is moved by the electric motor *o*, the uniformity of motion of which cannot be trusted for fine measurement over an interval of more than a few tenths of a second. The time standard is therefore taken from an interrupter, which cuts off the light falling upon the mirror at intervals of approximately a tenth of a second. The interrupter or vibrator *v* used is a simple steel tongue set in vibration and not maintained in any way. This tongue carries at its end a piece of wire which occults the slit S through which the light would otherwise pass.

The scale used can be varied within wide limits. As a rule the film is moved at a rate of 3·3 cm. per second, with a lateral displacement of the image of 0·13 mm. per milliampere, which would correspond to a magnification of the movement of the detector by about 1,000. The detector is shown in detail in Figs. 13 and 14. In Fig. 13 one of the soft iron faces *f* is removed, and in Fig. 14 the heads of the rods *h* have been removed. The detector consists of a short loop of platinoid wire (S.W.G. No. 36) under a tension of 4 lb., spanned by a small plane mirror *m*. The threads, 2 mm. apart, pass from the ivory crosshead at the upper end through the ivory guides *g*, across a span of 5 cm.

and are kept in tension by the spring *b*; the wires bearing the signal are screwed to the crosshead. By turning the heads *h* the detector and mirror can be slightly inclined to either side, as a final adjustment. The two stout brass screws *ss* keep the iron faces *f'* apart under the pressure of the pole pieces between which they are gripped.

The standardisation of the period of the vibrating tongue puzzled Professor Sampson for some time. It sometimes showed anomalies by comparison with the clocks tested, which sent the signal either directly off the pendulum, or indirectly through relays and other devices. In the first case the intervals were found concordant, in the latter case

Fig. 11.

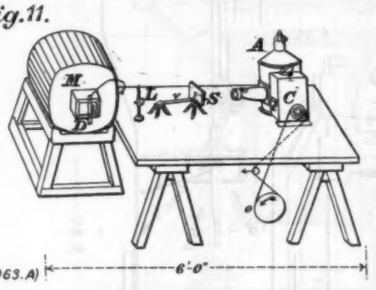
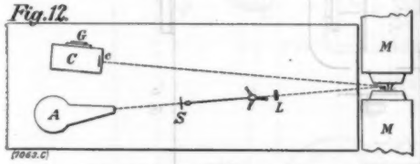


Fig. 12.



MICROCHRONOGRAPH DETECTOR.

Fig. 13.

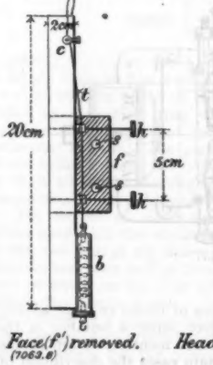
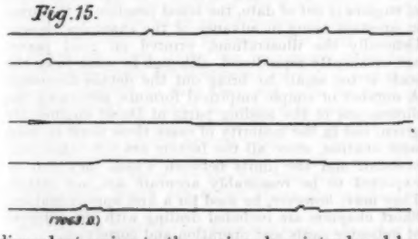


Fig. 14.

Fig. 15.



discordant owing to the various lags introduced by the accessory devices. Finally, a Cottingham clock was used for standardising directly off the pendulum.

The curves of Fig. 15, Professor Sampson remarked, were chosen for convenience; they hardly illustrated the best results obtained. On the second line from the top a slight hump would be noticed on the left-hand side; the hump indicated the point where the Synchronome clock had started its current, and where it had shut it off again after one-twentieth of a second. The spacings in the horizontal line—hardly visible in our diagram, we are afraid—marked tenths of a second; a line corresponds to 7 seconds. On the third line the thickening marked a lag obtained with a controlled clock. The further slides exhibited by Professor Sampson proved that the Cottingham clock gave second ticks concordant within 0·2 mil-second (*i.e.*, one-fifth of a thousand of a second). The seconds of the Synchronome clocks differed much more from another, by 3 mil-seconds sometimes, and their average accuracy was ± 1·1 mil-second. The two-second intervals given by a Riefler clock were found to fluctuate by fully 0·01 sec, the irregularity being due to the faulty cutting of the escapement wheel. The lag of a Fuess chronograph was found to be very uniform.

Star Streaming.

At the Cape Town meeting of 1905 Professor J. C. Kapteyn, of Groningen, Netherlands, had first announced that the stars seemed to move in two streams in opposite directions. That view was based on an exceedingly laborious analysis of the apparent motions in random directions of many stars. In his paper on a First Attempt of a Theory of the Structure and Motion of the Stellar System, he now suggested a dynamic explanation for the observational results. If we imagined the sun at the centre of the Gallaxy, he said, the equi-density surfaces of the stellar system for that part of the system, where the density was more than 0·01 of that near the sun, would approximately form concentric rotation ellipsoids, and the attraction of the whole on any point within this domain could be computed if we knew the average mass of a star. There were reasons to assume that the system rotated about the Polar axis of the Milky Way. To stars along this axis we might apply the barometric formula for determining heights in our atmosphere, that is, in a gas at rest. If the earth had twice its mass, the height of its atmosphere would be diminished; the change of density determined the form. From such calculations he found that, at distances from the centre of 198, 413, 717, 1114, 1660 parsecs, the average mass of a star should be 2·2, 2·0, 1·7, 1·5, 1·4 times the mass of the sun. These figures agreed surprisingly well with those deduced from binary star observations. The same values for the masses were obtained for the stars in the plane of the Milky Way if we added centrifugal force to gravitational force. At distances of 1010, 2106, 3657, 5675, 8465 parsecs we found linear star velocities of ± 13·0, 19·5, 20·1, 19·4, 18·6 km. per second. Assuming that one portion of the stars moved in one direction, and the rest in the opposite direction, the relative motion for the majority of the stars would be 2 × 19·5 km., *i.e.*, 39 km. per second. That velocity agreed with the relative velocity of the two star streams, and we thus obtained an explanation of the two streams if we assumed that the sun was not at the centre of the system, as was probable *a priori*. Only stars in the plane of the Gallaxy could have circular motion; outside that plane the motion must be peculiar, and that no curvature had so far been observed for the stream was due to the fact that the extent of the domain of star streaming seemed to be very small.

Sir Frank Dyson, thanking Professor Kapteyn for his important communication, expressed surprise that Professor Kapteyn should, in his mass estimate, have spoken of a relatively small dark mass; he also enquired how the stream direction came in. But there was no time available for a discussion of the paper.

The 72-in. Telescope of the Dominion of Canada.

The Astronomer Royal, Sir Frank Dyson, F.R.S., made a brief communication on the excellent work done in the past three years with the 72-in. reflecting telescope of the Dominion of Canada, an instrument of which we published a very full account in our issues of August 5, 12 and 19 last. The observatory is near Victoria, on Vancouver Island. Briefly describing this remarkable instrument, the largest in the Empire, Sir Frank also exhibited slides exemplifying the work which Dr. J. S. Plaskett is doing in conjunction with the Mt. Wilson Observatory, especially on the bright stars of the northern hemisphere and their velocities, and upon variables.

Radial Velocities of Stars.

In presenting a short statistical paper, the last read before the Section, Professor George Forbes, F.R.S., of London—an Edinburgh man by birth, as he mentioned—remarked that the title of his communication might also be "Solar Motion with Respect to the Stars." When nebulae and clusters were rejected from Voûte's first catalogue of 2071 radial velocities of stars, he said, the number of stars was 1,895, and their mean motion from the solar apex was: Right ascension, 18 hours 0 minutes, and declination + 27 deg. Campbell's catalogue I (280 stars) gave R.A. 18 hours, D. 27 deg. 0 minute, and his catalogue II (1,047 stars) R.A. 18 hours 8 minutes, D. 27 deg. 26 minutes. Taking these figures Professor Forbes deduced the mean radial velocities 22·73 (Voûte) and 19·9 and 17·7 (Campbell) in kilometres, per second.

Four-Dimensional Physics.

The "Four-Dimensional Physics," for which Professor E. T. Whittaker, F.R.I., pleaded, offer the advantage that the surface elements when referred to four axes, represent both the electric and magnetic vectors, and that they fully characterise the state of a field. But only a few people can hope to realise those advantages of a physics on Minkowski's lines, in which there is, as Professor Whittaker pointed out, complete parallelity as well as half parallelity, in which planes may intersect in planes, or in points or not at all in which lines are completely perpendicular, or half-perpendicular or not at all perpendicular, and in which there is no flux across the sides of the tubes of force.

The title of the other mathematical paper, read by the Rev. J. Cullen, S.J., of Stonyhurst, consisted merely of an identity-equation; the paper dealt with prime numbers and an error in Legendre's Théorie des Nombres.

(To be continued.)

NOTES ON NEW BOOKS.

The difficulty of making books of reference complete and trustworthy is very considerable, and any serious attempt to compile a biographical directory is bound to be laborious. That perseverence in such work meets with success when well directed, is shown by the considerable expansion of "*Who's Who in Engineering*" for 1921-22. This volume is edited by Mr. J. E. Sears, C.B.E., and is published at 31*s.* 6*d.* at 93 and 94, Chancery-lane, W.C. 2. The present volume is a good deal larger than the earlier issue, but in many instances the particulars of leading engineers are still brief. It is practically impossible for an editor to supply details without the co-operation of the subjects of the notices, but the number of facts generally given indicate that the editorial work is being very carefully carried out, though in a few cases the notices enter into rather unnecessary particulars. For the second issue the work is distinctly comprehensive and will doubtless become more complete with time. Its value is enhanced by the fact that it not only forms a biographical directory of engineers, but also one of prominent men, and further gives particulars of firms in the engineering and allied trades. There is also an index to engineering products, while its value as a book of reference is enhanced by a large section being devoted to engineering and technical institutions, technical training centres, research organisations, associations of manufacturers and employees, and technical journals.

That the field of study and research in naval architecture is an ever widening one is clearly shown by the sixty-third volume of the "*Transactions of the Institution of Naval Architects*," which has just been issued from the offices of the Institution, and may be bought from Messrs. H. Sotheran and Co., 43, Piccadilly, and 140, Strand, London. The volume contains a complete report of the spring meetings held in March last, and is rather more slender than usual, due to the coal stoppage necessitating the cancelling of the proposed summer meeting. There is enough, however, in the volume to justify it to rank amongst its predecessors, and this is saying much. A suggestion of the wide field covered is found in a *resumé* of its contents. The two leading papers—by Sir Eustace T. d'Eyncourt, K.C.B., and Mr. S. V. Goodall—contain a very close analysis of the principles and practice of warship design in Germany. We have the strength of submarine vessels discussed. The airship is brought prominently into view by the paper on the standardisation of data for calculations for design, &c. Regarding the mercantile marine, many phases are considered, the framing of ships, the spacing of transverse bulkheads, the deflection of bulkheads and of ships, and the life-saving appliances carried on board, all being contributions of an eminently practical character. The paper on mechanical gearing brought out one or two written communica-

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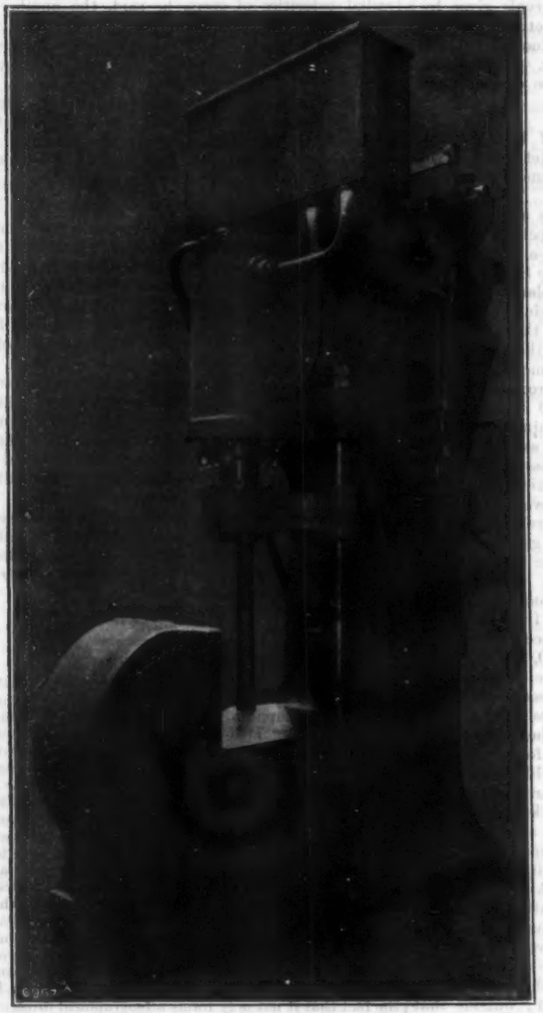

Fig. 1.

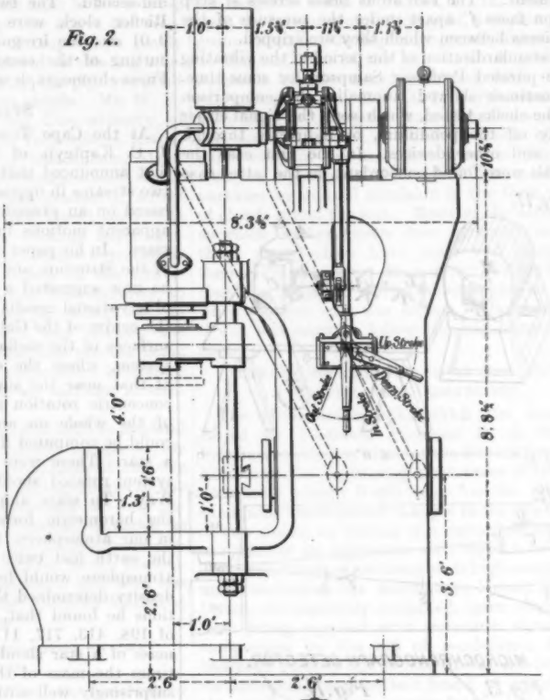

Fig. 2.

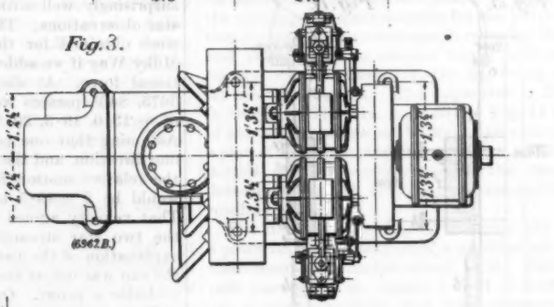

Fig. 3.

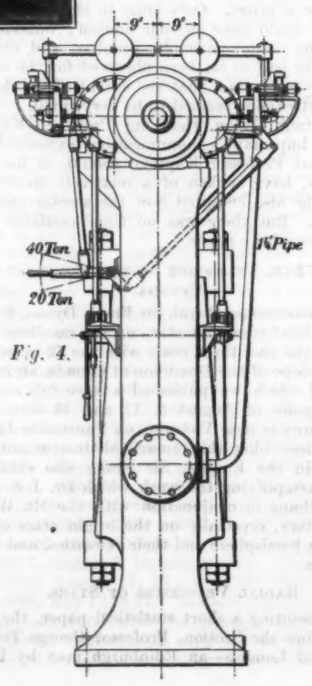

Fig. 4.

tions, in addition to the verbal contributions during the discussion at the meeting. This is also the case with the papers on "German Warship Construction." Constructor-Commander A. Nicholls, R.N., points out that the most recent German large cruisers were built on an almost purely longitudinal system of framing, which is admirably designed, and has, according to his information, the effect of saving a considerable amount of weight of hull. Light cruisers also are framed on this principle, but the battleships are built on the combined longitudinal and transverse system. He added that German constructors claimed the longitudinal system used as being their own development, but, in his view, it has a remarkable similarity to the type which was successfully introduced into this country—obviously meaning the Isherwood system. Mr. Dana, who is responsible for the editing, has done his work with his characteristic care, and it will be a gratification to the members to have the very fine portrait of the late president, the Earl of Durham, as the frontispiece to the volume.

A widening field of application of the Diesel engine ashore and afloat, and the consequent desire for information, is responsible for the increase in the number of text-books dealing with this prime mover. "*Marine and Stationary Diesel Engines*," by A. H. Goldingham (E. and F. N. Spon, Ltd., 15*s.* net), is a volume of 206 fully-illustrated pages, within which limited scope it is, of course, impossible to treat the subject fully. The most valuable features of the book are the illustrations and plates of various types of Diesel engines, which, whilst by no means complete (since a number of the most important types are not mentioned) are in the main well chosen. In certain cases the description of types of engines is out of date, the latest practice of the firms in question being in advance of the examples chosen. Generally the illustrations, printed on good paper, are excellently reproduced, although in some cases the scale is too small to bring out the details discussed. A number of simple empirical formulæ governing the dimensions of the leading parts of Diesel engines are given, but in the majority of cases these must be used with caution, since all the factors are not taken into account, and the limits between which they can be expected to be reasonably accurate are not stated. They may, however, be used for a first approximation. Short chapters are included dealing with the subjects of indicator cards and operation and correction.

SPRING BUCKLING PRESS.

A spring buckling press fitted with oil transmission is illustrated in Figs. 1 to 8, on the present and opposite pages. The press is intended for locomotive and motor car spring work, and will operate with pressures of 20 and 40 tons on the horizontal and vertical cylinders. The ends of the rams are arranged to take shoes of various types according to the work to be done, and the size of the spring buckle to be operated upon.

On the head of the column are arranged two Hele-Shaw variable stroke pumps, driven by an electric motor of 15 h.p. One pump is provided for the horizontal and one for the vertical ram of the press. The two pumps as will be clear from the plan, Fig. 4, are driven by the one motor placed between them,

SPRING BUCKLING PRESS.

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Fig. 5.

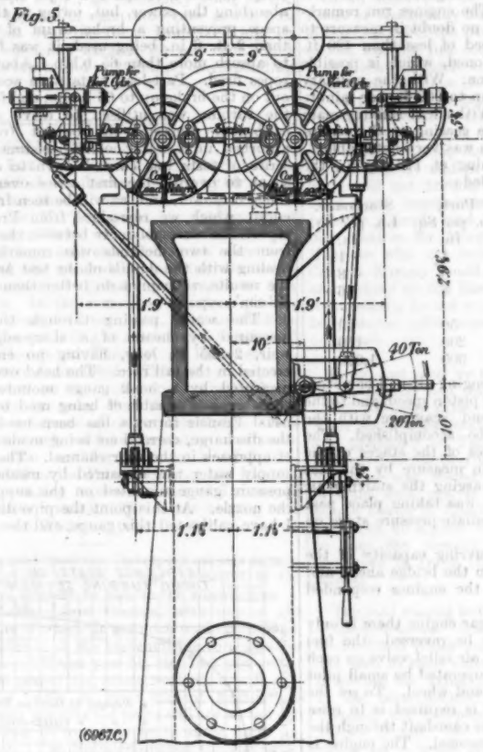
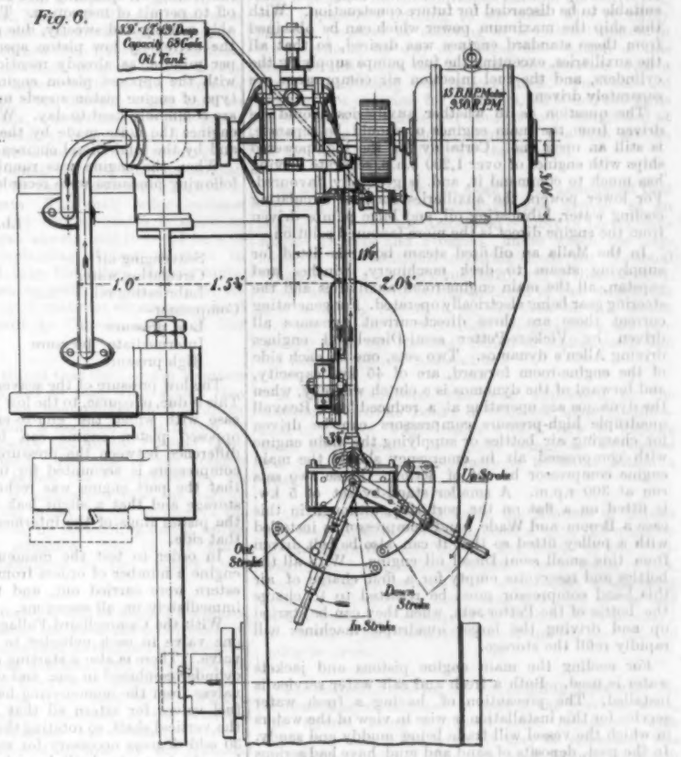


Fig. 6.



through gearing. Also on the head of the machine is an oil supply tank for the working fluid.

As is well known the action of the Hele-Shaw pump is controlled by a floating ring whose position with regard to the shaft is dependent upon the adjustment of an horizontal spindle. The pistons rotate in the case with the cylinder body, the latter being concentric with the shaft while the floating guide ring may be placed eccentrically or otherwise with the shaft as desired. The degree of eccentricity determines the action of the pump and the stroke of the pistons. In this case the two pumps are independently controlled by hand levers best seen in Figs. 2 and 6. One of these acts direct on levers on the near side of the machine, and controls the pump working the vertical piston. The other is fixed to a spindle extending through the column, on the far side of which levers and links run up to the second pump for the horizontal ram. These levers control the movement of the floating ring, as required to send the oil in one direction or the other. In order that there may be no load on the hand of the man operating these levers the movement is made through cams which are illustrated in Figs. 7 and 8. These are designed so that they will hold the load, while adjustment by hand is made with ease. The floating ring of a Hele-Shaw pump tends always to work back to the central neutral position. This movement is prevented, once the spindle has been moved over by the hand lever, by the weighted bell cranks, the weights of which are shown above the machine in Figs. 4 and 5.

Standing out from the machine and seen on the side of the column in Figs. 1, 4 and 5 is a small lever for regulating the control to either 20 tons or 40 tons. This regulation is effected by moving the fulcrum block of the bell crank lever, up or down, so as to alter the leverage to suit the desired pressure. This arrangement is shown best in Fig. 5. When the pump has worked up to this pressure the weight will lift and the floating ring will tend to work back to the central position, shutting off the supply to the ram cylinder, actually returning to a position in which the pump will just make good its own leakage. A certain amount of hunting occurs in maintaining the pressure by this means.

As the ram cylinder volumes are unequal on the two sides of the ram pistons, a by-pass is arranged for each pump for the reverse, and the surplus oil is returned to the tank above the press. The machine weighs about 8½ tons, and has been built by Messrs. Samuel Denison and Son, Limited, hydraulic engineers, of Hunslet Foundry, Moor-road, Leeds, for the spring department of Messrs. Samuel Osborn and Co., of Sheffield, a firm whose shops are operated throughout by electricity.

Fig. 7.

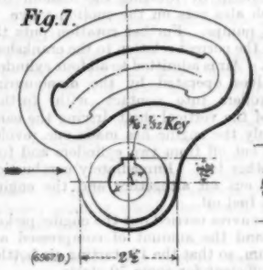
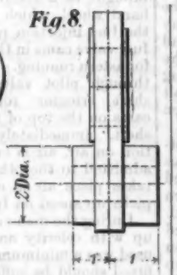


Fig. 8.



THE CAMMELLAIRD-FULLAGAR ENGINED M.S. "MALIA."

The year 1921 will mark the greatest progress to date in the introduction of Diesel machinery in the mercantile marine in any one year. A number of interesting motor ships have already been completed and are now in service, and before the end of the year further examples of different types are due for completion. Progress in this development, as with all others appertaining to shipbuilding, has been gravely impeded by the joiners' strike, the recent conclusion of which will enable a large number of motor ships to be commissioned this year.

With the latest ship engined with internal-combustion machinery, the M.S. Malia, built by Messrs. William Hamilton and Co., Port Glasgow, for Messrs. T. and J. Brocklebank, Liverpool, for their Indian trade, successful trials on the Clyde were run on Thursday, September 29. The machinery, consisting of a twin-screw set of Cammellaird-Fullagar Diesel engines, was built by Messrs. Cammell Laird and Co., at their Birkenhead engine works, and fitted on board by them at Glasgow. The necessary shafting, propellers, auxiliary plant, &c., was installed by Messrs. David Rowan and Co., of Glasgow, who are licensees for the construction of this type of marine oil engine.

The M.S. Malia is 365 ft. in length overall, 350 ft. between perpendiculars, 50 ft. beam, 27 ft. 3 in. moulded depth, of 3,880 tons gross and 6,000 tons deadweight on a draught of 23 ft.

The twin-screw machinery is slightly abaft of amidships. The main engines need not be described in detail, since reference can be made to a full description published on the occasion of the successful bench trials of the first mercantile marine engine of this type built at Birkenhead (see Engineering, vol. cix. page 144, January 30, 1920). Each engine consists of two units, and each unit has two cylinders and four pistons, working on the opposed piston principle, with the distinctive Fullagar characteristic that the upper piston in each cylinder is coupled by oblique rods to the lower piston of the adjacent cylinder. There are two connecting rods and two cranks to each unit. The cylinder diameters are 14 in. and the stroke of each piston is 20 in., so that the effective stroke is 40 in., and running at 125 r.p.m. a power of 550 b.h.p. or 730 i.h.p. is obtained. At this output the brake mean effective pressure is 71 lb. per square inch, with an indicated mean pressure of 94. The piston speed at full revolutions is the low figure of 417 ft. per minute. The engine works on the two-stroke cycle principle for which the opposed piston type of construction permitting of a straight through scavenge from one end of the cylinder to the other is particularly well suited. The scavenging air is supplied from four pumps, formed by the crossheads of the four upper pistons, to a reservoir in the engine cylinder entablature whence it enters the main cylinder when the ports are uncovered by the main pistons. Air injection of the fuel is adopted, the air being supplied by a three-stage vertical compressor driven from an extension at the forward end of the main crankshaft. Of the two engines installed in this vessel the port engine is that with which the Fullagar—the electrically-welded ship—was fitted. This ship was experimental, and it was found that the engine was of more power than was required, so that it is being replaced by a "Beardmore" semi-Diesel oil engine of 320 b.h.p. The starboard engine is a new engine of the same design as the port engine, but to the opposite hand. The engines are exactly alike in every particular except as regards the arrangements for piston cooling. With the starboard engine the telescopic tube system of leading the water to the pistons is adopted, whereas with the port engines a combination of flexible pipes and swinging levers is fitted. With

this latter arrangement it is claimed that leakage is impossible, although only time can prove whether the special rubber hoses employed will be sufficiently oil-resisting to be fully reliable. The fitting of these two types of gear is exceedingly interesting as making a direct comparison possible and enabling the least suitable to be discarded for future construction. With this ship the maximum power which can be obtained from these standard engines was desired, so that all the auxiliaries, excepting the fuel pumps supplying the cylinders, and the fuel injection air compressors are separately driven.

The question as to whether auxiliaries should be driven from the main engines or should be separate, is still an open one. Certainly for the high-powered ships with engines of over 1,200 b.h.p. separate driving has much to commend it, and is generally favoured. For lower powers the auxiliaries such as circulating cooling water, lubricating oil, and bilge pumps driven from the engine direct is the more favoured solution.

In the Malia an oil-fired steam boiler is fitted for supplying steam to deck machinery, winches and capstan, all the main engine-room auxiliaries and the steering gear being electrically operated. For generating current there are three direct-current dynamos all driven by Vickers-Petter semi-Diesel oil engines driving Allen's dynamos. Two sets, one on each side of the engine-room forward, are of 45 kw. capacity, and forward of the dynamos is a clutch whereby, when the dynamos are operating at a reduced load, Reavell quadruple high-pressure compressors can be driven for charging air bottles or supplying the main engine with compressed air in emergency should the main engine compressor be out of action. These two sets run at 300 r.p.m. A smaller stand-by set of 5 kw. is fitted on a flat on the port side, although in this case a Broom and Wade hand compressor is installed with a pulley fitted so that it can also be belt driven from this small semi-Diesel oil engine. With all the bottles and reservoirs empty for a first charge of air this hand compressor must be resorted to to charge the bottle of the Petter sets, when they can be started up and driving the larger quadruple machines will rapidly refill the storage.

For cooling the main engine pistons and jackets water is used. Both a fresh and salt water service is installed. The precaution of having a fresh water service for this installation is wise in view of the waters in which the vessel will trade being muddy and sandy. In the past, deposits of sand and mud have had serious effects on the parts into which they carried by the cooling water. Fresh water is circulated by two Albany pumps driven through gearing by electric motors and located at the forward end of the engine-room. The fresh water circulates in a closed circuit containing a cooler through which is pumped a supply of salt water from two centrifugal Drysdale motor-driven pumps.

On the starboard side a Drysdale centrifugal ballast-pump and a similar bilge-pump with electrical drives are fitted. The centrifugal ballast-pump is provided with an air extractor to ensure a satisfactory suction even should the long ballast pipe line be air locked. For a second bilge-pump an electrically-driven geared pump is installed also on the starboard side, whilst an emergency steam-driven ballast and boiler feed-pump are located on the port side.

At the after end of the engine-room, between the two Michell thrust blocks, are two Albany geared wheel type rotary pumps for supplying the forced lubrication oil system. Where two pumps are fitted as for circulating water, lubricating oil, &c., one serves normally to supply both engines, the other being a stand-by.

For starting and manœuvring there are provided 12 large air bottles charged to a maximum working pressure of 1,000 lb. per square inch, and for injection of the fuel and served by the main engine injection compressors are three air bottles. The mains from the air service, both for starting and injection, are led to a valve box between the two engines, where charging, blowing down, &c., can be effected by manipulating the valve wheels. These are arranged in a very neat manner, analogous to the control of electric power at a switchboard. In the engine hatch two large settling tanks for the main engine fuel oil are placed.

Throughout the trial the oil used by the main engines, the semi-Diesel auxiliaries (of which one was running all the time) and the donkey boiler fitted with Smith's Dock oil fuel-burning gear, was the same, viz., Anglo-American fuel of 0·90 density.

Throughout the trials the main engines ran well. Only the least vibration was noticeable at the scavenging pump covers at the top of the engine. The exhaust was almost smokeless, and what slight haze was noticeable no doubt was attributable to the extra quantity of lubricating oil fed to the scavenging pumps and main pistons, as is usual during trials with new machinery. The exhaust, moreover, as judged on deck, was very silent, indicating a more efficient silencer than is usually fitted to two-stroke cycle engines, the silencing of which is a problem of some considerable interests. The silencers are placed in the funnel.

For the benefit of those interested on board, the guards with which the engine is fitted to prevent lubricating oil splashing into the engine-room were left off to permit of inspection. The engines run remarkably silently and sweetly, due no doubt in measure to the extremely low piston speed of less than 420 ft. per minute, as already mentioned, which is possible with the opposed piston engine. With the ordinary type of engine piston speeds up to 900 ft. per minute are commonly used to-day. With silent running main engines the noise made by the gearing of the pumps and by the semi-Diesel engines was very noticeable.

When the engine was running at 116 r.p.m., the following pressures were recorded :—

	Port. Lb. per Sq. In.	Starboard. Lb. per Sq. In.
Scavenging air	1¼	1¼
Circulating water	8	8
Lubricating oil	8	6
Compressor—		
Low pressure	50	33
Intermediate pressure	200	160
High pressure	900	1,000

The low pressure of the scavenging air will be noted. This is due, of course, to the low piston speed, and to the ease with which the end-to-end scavenge with the opposed piston engine can be accomplished. The difference between the pressures of the stages of the compressors is accounted for in measure by the fact that the port engine was recharging the starting air storage and that a slight leak was taking place past the piston rings of the intermediate-pressure stage on that side.

In order to test the manœuvring capacity of the engine a number of orders from the bridge ahead and astern were carried out, and the engines responded immediately on all occasions.

With the Cammellaird-Fullagar engine there is only one valve in each cylinder to be reversed—the fuel valve. There is also a starting air relief valve on each cylinder combined in one, and operated by small pilot valves from the manœuvring hand wheel. To set the fuel valves for astern all that is required is to raise the vertical shaft, so rotating the camshaft through the 30 odd degrees necessary for reversal. The engine is brought to a standstill by rotating the manœuvring hand wheel, which also acts on the suction valve of the fuel injection pumps. Further rotation puts the fuel valve cams in the correct relation to the crankshaft for astern running. Air is admitted to all four cylinders through pilot valves operated by the manœuvring shaft bringing rollers into contact with further cams on the top of the vertical shaft driving the camshaft. Immediately the engine has made one revolution on air, air is cut off from two cylinders and fuel admitted to the other two. Immediately combustion takes place air is cut off altogether and the engine picks up speed on fuel oil.

During the manœuvres carried out the engine picked up with celerity and the amount of compressed air used was a minimum, so that the 12 starting air bottles fitted should be sufficient for some 70 starts.

A feature of the engine is the simplicity and accessibility of the control of the fuel injection pumps. The suction valves are operated in the usual way by tappets fulcrummed in eccentric bearings.

With the engines developing a total of 1,460 i.h.p., a speed of 10¼ knots was attained. The consumption of lubricating oil was 0·003 lb. per b.h.p. per hour and of fuel oil 0·42 lb. per b.h.p. per hour, taking the brake horse-power at 1,100.

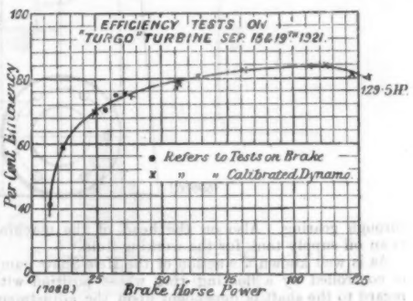
This motor ship was constructed under the supervision of Messrs. G. S. Goodwin and Co., of Liverpool, to the requirements of Lloyd's Registry.

TESTS OF AN IMPULSE WATER TURBINE.

An example of a new type of impulse water turbine which has recently been introduced by Messrs. Gilbert Gilkes and Co., Limited, of Kendal, has been installed at Invergeldie, near Comrie, in Perthshire, on the property of Mr. W. W. Hood. This machine has an 18 in. diameter runner and is rated at 109 b.h.p. It runs at 640 r.p.m. and works on a net head of 200 ft. After the turbine had been running for some weeks under working conditions a series of efficiency tests were carried out on it by Professor A. H. Gibson, of the University of Manchester, and by the permission of Mr. Hood we are enabled to publish the results of these tests. The speed of the turbine is controlled by the makers' patent shaft deflector governor, fitted with a water economiser, but during the tests the economiser mechanism was disconnected and locked so as to enable the quantity of water used to be controlled independently of the load on the turbine. This governor is so rapid in its action that with the whole load suddenly thrown off the momentary rise in speed does not exceed 2 per cent. This result is obtained without any special flywheel effect.

The tests were carried out on September 16 and 19 last. In the first series a rope brake was used for absorbing the power, but, owing to the limitations of space preventing a brake drum of larger diameter than 2 ft. 6 in. being used, it was found impossible to absorb more than 65 b.h.p. Above this load the ropes fired. Part-load tests were accordingly carried out on the brake up to 65 b.h.p., and for higher powers the turbine was utilised to drive a direct-coupled calibrated dynamo, the output from which was absorbed in a water-cooled resistance. This second series of tests was carried down to about 25 b.h.p., so as to overlap the first series over a considerable range of power, and, as will be seen from the annexed curve, which we reproduce from Professor Gibson's report, the correspondence between the results obtained from the two methods was remarkably close. In dealing with the details of the test arrangements and the results, we cannot do better than quote Professor Gibson's report :—

"The water passing through the turbine was measured by means of a sharp-edged rectangular weir, 2·995 ft. long, having no end contractions, erected in the tail race. The head over the crest was measured by a hook gauge mounted in a stilling chamber, and capable of being read to 0·01 in. The usual Francis formula has been used for computing the discharge, corrections being made for the velocity of approach in the weir channel. The pressure of the supply water was measured by means of a Bourdon pressure gauge mounted on the supply pipe behind the nozzle. At this point the pipe diameter is 10 in. I have calibrated this gauge, and the readings of the



head have been corrected for gauge errors, for the height of the gauge above the jet, and for the velocity of approach in the supply pipe. The rope brake is 2 ft. 6¼ in. diameter to the centre of the ropes. Salter's spring balances were used to measure the tensions in the brake ropes. I have calibrated these balances against dead weights, and the recorded results are corrected for any error of the balances. The revolutions were measured by tachometer, calibrated against a revolution counter. The output from the dynamo was measured by ammeter and voltmeter, which have also been calibrated. The calibration of the dynamo was carried out by its makers.

"*Test Results.*—The results of the tests are shown in the following tables and in the accompanying curve :—

Tests with Brake Load.

Expt.	Revs.	Head.	B.H.P.	Q.(c.f.s.).	W.H.P.	Efficiency.
1	629	212·4	7·06	0·723	17·46	0·405
2	629	211·5	12·00	0·848	20·35	0·590
3	629	208·1	27·95	1·668	39·52	0·709
4	629	207·8	32·80	1·862	44·00	0·745
5	629	206·9	36·22	2·053	48·25	0·751
6	629	218·2	56·80	2·882	71·55	0·793
7	623	211·6	64·81	3·350	80·50	0·805

Tests with Dynamo Load.

Expt.	Revs.	Head.	K.W.	B.H.P.	Q. (c.f.s.).	W.H.P.	Efficiency.
8	639	230·2	14·86	24·76	1·360	25·59	0·696
9	640	226·6	25·30	39·22	2·021	39·22	0·754
10	635	225·0	37·15	56·25	2·841	72·50	0·776
11	638	225·0	37·92	57·30	2·860	73·05	0·784
12	640	210·6	54·30	80·95	3·941	98·26	0·824
13	640	218·3	71·62	106·3	5·14	127·6	0·834
14	640	217·3	76·00	113·0	5·49	125·2	0·835
15	632	212·2	82·51	122·5	6·29	151·8	0·806
16	615	221·0	86·90	129·5	6·49	162·9	0·795

"The mean head in the first series of tests was 210·9 ft. and in the second series 221·7 ft. The mean

speed in the first series was 628 r.p.m. and in the second series 635 r.p.m. An examination of the efficiency curve shows that, over the range common to both series of tests, the results are sensibly identical. The results show a maximum efficiency of 83·5 per cent. at about 110 b.h.p., an extremely good result, especially for a turbine of such moderate power. It will be noted that over the range from 60 b.h.p. to 125 b.h.p. the efficiency exceeds 80 per cent., and that even with so low a load as 25 b.h.p., corresponding to 20 per cent. of full load, the efficiency is 75 per cent."

INDUSTRIAL NOTES.

DURING the last week-end the Premier held a conference at Gairloch which was attended by Sir James Simpson, Sir Alan Smith, Sir John Dewrance, Mr. W. L. Hichens, Mr. W. T. Layton, Mr. Dudley Ward and Mr. Pembroke Wicks. It will be noted that the engineering and iron and steel industries were well represented, and the general subject for discussion was the best means of giving an impetus to this country's trades. In the somewhat overdone phrase, so dear to the present Government, various avenues were explored, but according to a brief speech delivered by Mr. Lloyd George on Tuesday, at Inverness, no definite plans were formulated. This, of course, was only to be expected, as the conference was called in an advisory capacity in order that the Prime Minister might have the assistance of expert knowledge. It is understood that much useful information was made available, but that nothing was to be definitely announced until after the Prime Minister has had the opportunity of meeting representatives of Labour, in a somewhat similar manner. This latter meeting took place in London on Wednesday.

It cannot be said that the Inverness speech carried matters any further, though it was indicative of the Prime Minister's anxiety to handle the situation in an effective way. Mr. Lloyd George, with one of the bright metaphors of which he has such ready command, likened foreign trade at the present time to a game of billiards at sea. "When you hit the ball you never know into what pocket (or whose pocket), it will go." With exchanges liable to their present fluctuations it is indeed a case whether the profit will not at the end of the transaction be found to be in some quite unexpected pocket. The Premier quoted the somewhat extreme example of the Polish mark, but the extraordinary behaviour of the German mark is equally astonishing, for in Germany, from all accounts, practically the whole of the industrial nation is working hard for rehabilitation.

When on the matter of exchanges the Premier remarked that the paper money of Russia was not quoted on any earthly exchange though the country was considered a paradise by one school of extremists, and warned people against those who thought they were increasing national wealth every time they turned out a fresh batch of Treasury notes. This remark, which comes rather near home, was supplemented by the reminder that our coat had to be cut according to the cloth, and that we could not pay out in doles what was not in the public treasury. In closing, Mr. Lloyd George said we would only proceed from crisis to disaster if any one class seized upon the present difficulties as giving the opportunity for extorting something which was unfair to others.

In an interview reported in the *Morning Post* of Wednesday last, Mr. W. L. Hichens said that an attempt to trade first and stabilise exchanges afterwards was like putting the cart before the horse. In the matter of reducing production costs Mr. Hichens said they required the co-operation of the trades unions in the use of labour-saving devices, the wages of skilled and unskilled workers, &c. With an effort on the part of trades unions to reduce costs a great deal might be effected, and this country put in a position to meet German competition, but without such help employers would find themselves unable to pay any wages at all,

Apropos of Mr. Lloyd George's and Mr. Hichens' remarks on foreign exchanges, we may remind our readers that Sir Alfred Mond, as recently as September 27 pointed out that in pre-war times three-fourths of our trade was with our Colonies and Dependencies, the Far East and South America, while, with the exception of Germany, only very little was done with Central Europe and those countries whose exchange is heavily depreciated at the present time. He considered the situation hopeful because of this fact, which rather discounts the remarks of Mr. Lloyd George and others concerning the effect of recent fluctuations. Such trade, however, can only revive on a healthy basis when we can bring the selling price of our commodities within the reach of possible customers in the more stable countries we wish to trade with. If we can produce at an attractive price, subject to a little delay, perhaps, the revival must ultimately come, in a world so behindhand in its needs as this is on account of the war.

In an interview, of which a report is given in the *Times* of Wednesday last, Mr. B. H. Morgan, chairman of the Council of the British Empire Producers' Organisation, who has just returned from Canada, states that, if this country made the effort, it could within a very short time increase its export trade to the Dominion by at least £50,000,000. Mr. Morgan states that an immense amount of trade, which Canada would prefer to see coming to this country, is now being done with the United States, merely because that country can supply quickly and in small parcels, whereas English firms will not trouble to carry stocks in Canada to meet such requirements The mail order business between Canada and the United States is quite as important as Mr. Morgan asserts, and it would be well if those who are complaining of lost markets in Central Europe would take Sir Alfred Mond's hints, and, acting on the lines suggested by Mr. Morgan, see if something in the way of material expansion cannot be fostered with regard to Canada and such like countries.

In our last issue we stated that the London Members of Parliament had decided to take what action they could to help solve the unemployment difficulties. After some consideration a document was drawn up and presented on Tuesday last to the Cabinet Committee on Unemployment. The case of the London Members was stated before the Committee by Sir William Bull, and it is understood that the various public bodies in London might, in the opinion of the members, do a good deal, by forwarding useful works, to ease the present situation. The list of works suggested is being considered by the Cabinet Committee.

The coal mining industry is still in need of a solution of its difficulties. During the week the leaser quest on of the South Wales coalowners' liabilities for September has been to some extent overshadowed by a wider one involving the fixing of the rate of wages for October. It has been decided to refer both to Sir William Plender, the independent chairman of the National Wages Board. Sir William has recently given a ruling on a point referred to him by the National Board to the effect that where a district wage falls below the maximum reductions for the temporary period, the difference in October should be met by the owners to the extent of the aggregate net profits of the district for July and August. The wages payable in October, November and December are to be based on the ascertained results for August September and October. The national settlement made no provision for maximum reductions in October, as the "temporary" period only covered July, August and September. Sir William Plender has, therefore, been asked to give an interpretation of his award quoted above, pending which the South Wales question will be held over.

On Monday last notices were posted in several collieries in the North Wales district stating that they would be closed till further notice. The reason is stated to be that the high cost of working, with the present scales of wages, makes it impossible to carry on the industry.

The recent ballot taken by the National Federation of Colliery Enginemen and Boilermen, on the question of severance from the Miners' Federation, was declared on Friday last at a Southport meeting to be overwhelmingly in favour of the National Federation being free to manage its own affairs. It was stated that a working arrangement with the Miners' Federation would not be objected to so long as dictation was rendered impossible. At the same time it s reported that the Durham County colliery enginemen have seceded from the National Federation.

A meeting was held in London on Tuesday of unions covering colliery enginemen, colliery mechanics, electricians, &c., to consider the question of setting up a special organisation representing these grades, and with a view to an alteration in the constitution of the present National Federation of Colliery Enginemen and Boilermen in order to meet the requirements of mechanical and electrical sections. The workers represented number about 100,000. Dissatisfaction is expressed at the settlement arrived at by the Miners' Federation, in which it is stated the interests of the workers in these categories were not properly considered. A committee was appointed to go into the question of linking up the bodies represented at the meeting.

The serious effect of the independent attitude of labour was further exemplified by a case at Shields in which, on Saturday last, trimmers refused to work half an hour overtime after 12 o clock, in order to complete a vessel for sea. An offer of £50 made to the men was refused, with the result that the vessel was detained over the week-end. The large loss of the ship standing idle, together with the additional harbour dues involved, were apparently nothing to the men, who probably had the prospect of assisting at a football match in the afternoon, by way of looking on. Action of this kind certainly does not look like co-operation with a view of extending our export trade. The scale of payment for overtime for trimmers, for which the Tyne owners have offered 3*s* per hour, is to be considered at a conference to be held in London. The men ask 4*s*. for the first hour and 5*s*. for the second.

As we went to press last week it was announced that the Scottish railway companies had arrived at an arrangement with the Associated Society of Locomotive Engine Drivers and Firemen, under which the payment of the additions resulting from the National Wages Board award of June, 1920, will be discontinued. These amounts will be discontinued in two stages, the first becoming operative on the 17th of this month and the second in December. Negotiations are proceeding with the National Union of Railwaymen and the Railway Clerks' Association.

A small committee has been appointed by the National Maritime Board to consider some modification of officers' wages scales with a view to making them more elastic. The joint committee appointed has full powers and instructions to settle within a week.

As we mentioned last week, the Minister of Labour had been appealed to in connection with the question of the discontinuance of the war bonus in the engineering and shipbuilding trades. As a result of this, negotiations as regards the engineering trade were resumed between the employers and men at the end of last week, but adjourned till yesterday (Thursday). No decision had been announced up till the time of going to press.

The output of coal for the week ending September 24, showed a small increase on that of the previous week, the figures being 4,273,000 tons, compared with 4,161,700 tons. The latter, it may be remarked, was 221,900 tons higher than the week before, in which however, the output had shown some decline.

Sir Arthur Duckham, speaking at the Society of British Gas Industries, on Wednesday, said that recent discussions of wage problems had been altogether on a false basis. The question was not one of either high or low wages, but of whether the wages paid had been earned by the recipient. Cash payment to unemployed for no work ought to be abolished. He considered that redemption of the war debt should be deferred for five years.

At the League of Nations Union, on Wednesday, Lord Cowdray said he considered the nation to be insolvent at the present time, and we were becoming poorer every year. The Government required about 1,000,000,000*l*. a year, and this country at the most was capable of paying about 900,000,000*l*. Before the war we used to have about 400,000,000*l*. to invest in industry, &c.; now the Government took the whole.

AGRICULTURAL MACHINERY IN CHINA.—British manufacturers of simple and inexpensive agricultural machinery and hand implements are advised to communicate with the London agents of British engineering firms established in China. A list of such agents is obtainable on application to the Dept. of Overseas Trade, 35, Old Queen Street, Westminster, S.W. 1., quoting reference No. 6148/FE/PN. His Majesty's Commercial Counsellor for China would be glad to receive catalogues and price lists for use in his office at Shanghai.

UNITED STATES AND BRITISH NAVAL CONSTRUCTORS.—Commander E. S. Land, of the United States Navy Construction Corps, who has been Assistant Naval Attaché in this country for the past two years, is returning to America next week. On Tuesday, the 4th inst., the members of the Royal Corps of Naval Constructors entertained him and his successor, Commander E. C. Hamner, at lunch at the Carlton Restaurant. Later the Director of Naval Construction presented him with a golf trophy for competition amongst the members of the United States Navy Construction Corps. In making the presentation Sir Eustace d'Eyncourt expressed the hope that it would be a reminder of the friendly co-operation between the Construction Corps of the two countries which led to such happy results during the war. In accepting the trophy, Commander Land expressed the opinion that the mutual regard won during those times could never be obliterated, and that anything which tended to cement the friendship and cordial relations between the two countries could not fail to be for the benefit of civilisation and world-wide peace.

HORIZONTAL SURFACE GRINDING MACHINE.

CONSTRUCTED BY THE GRAHAM MANUFACTURING COMPANY, ENGINEERS, PROVIDENCE, R.I., U.S.A.

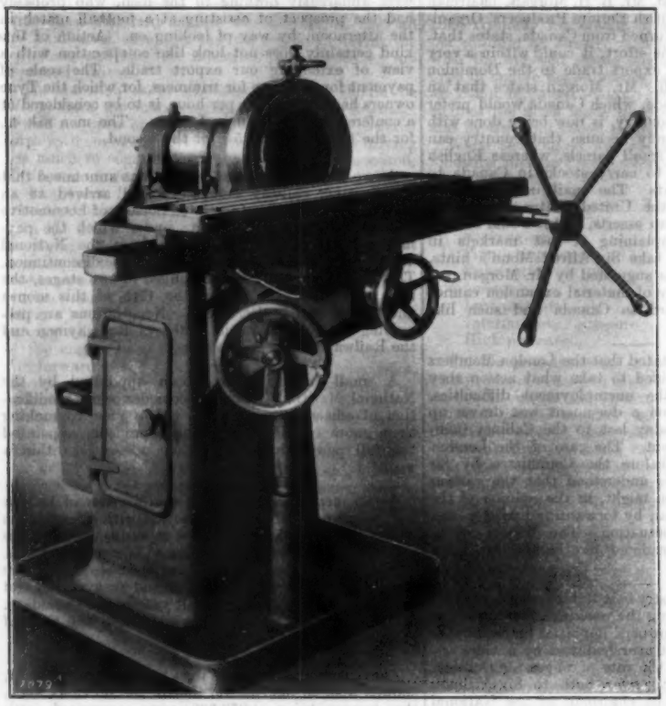


Fig. 1. Front View of Machine.

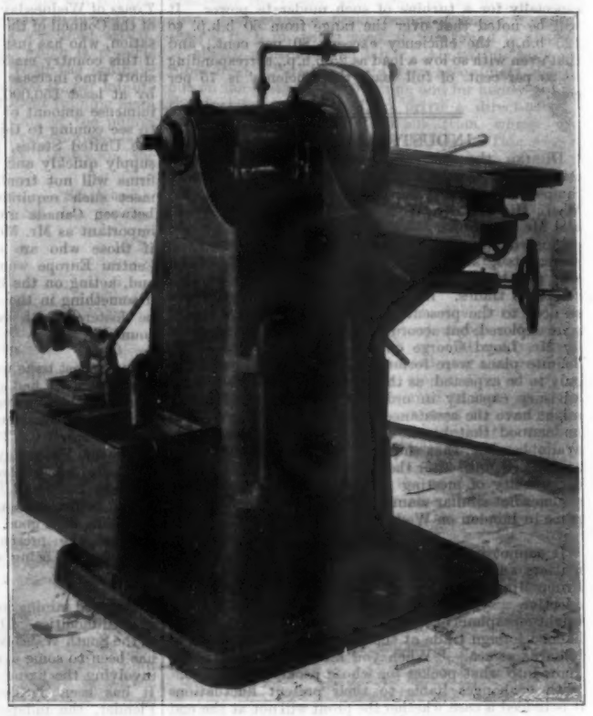


Fig. 2. Rear View of Machine.

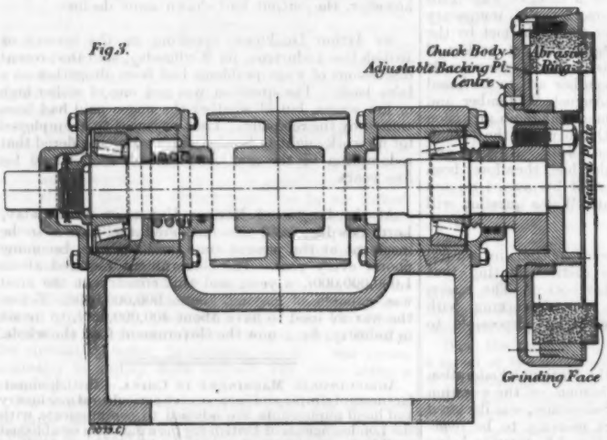


Fig. 3.

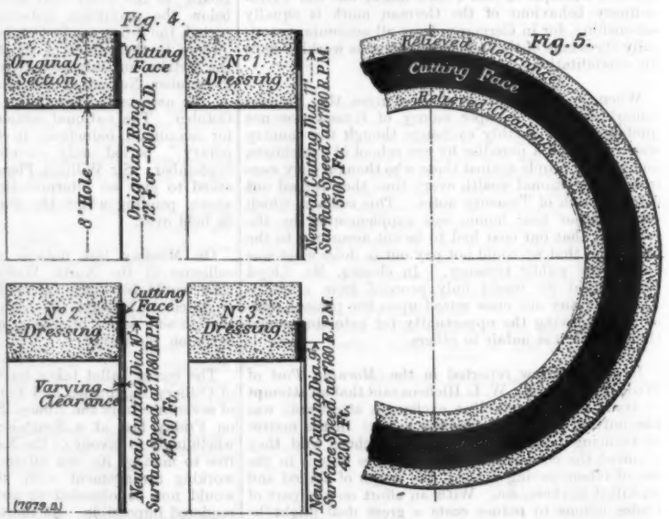


Fig. 4.

Fig. 5.

An interesting but simple surface-grinding machine, which is built by the Graham Manufacturing Company, of 71, Willard-avenue, Providence, R.I., U.S.A., is illustrated in Figs. 1 and 2 above. The simplicity of this machine is a not unimportant feature. There is practically nothing in it to go wrong, or which cannot be understood by any ordinary mechanic. It requires no expert from the makers to first set it up, and is very suitable for operation by unskilled labour. The general features of the machine will be clear from the figures. It consists of a pedestal carrying an horizontal spindle at the top, at one end of which the abrasive wheel is attached. A ring wheel is used, and the grinding is done by the outer face of the wheel. One face of the pedestal carries a knee bracket, and on this a compound slide works. Hand wheels for vertical motion, cross traverse and travel in and out are fitted. The table is provided with Tee slots for securing the work. A suds tank with pump is fixed at the back of the machine and ample splash guards are provided in conjunction with the wheel and work table. These are removed in Figs. 1 and 2 in order that the details of the machine may be more clearly seen. The tool as shown is arranged for driving by belt from a counter-shaft, but a direct motor drive may be employed, with the motor carried on a bracket at the back of the machine, and connection to the spindle made through a flexible coupling.

It will be clear that the whole arrangement forms a rigid construction. As will be seen from the section of the spindle given in Fig. 3, the overhang has been reduced to a minimum. It will be evident from this figure that the head of the machine is cast separately and is bored for two bushes, which carry Timken roller bearings. It is obviously important that end play should be reduced to a minimum in a machine of this kind; the rear bush is accordingly made a close sliding fit in its housing, and a stiff helical spring is introduced as shown, which automatically takes up end motion and wear. A malleable castellated nut, with a cotter pin at the end of the spindle provides for adjustment. The bearings run in oil and felt-packed collars protect them from dust produced by the machine. Oil-level indicators are fitted. The method of mounting the abrasive ring is a special feature of the machine. As will be seen from Fig. 3, the holder consists of a heavy hub to which a machined pressed steel body is fastened. This body is tapered inside its flange and a cone-shaped ring, which is drawn inward by screws, grips the outside of the abrasive wheel and holds it in place. The back of thewheel bears against a flange, which screws on the boss of the housing and can be adjusted outwards as the wheel face wears down.

In the design of the machine special attention has been paid to the question of wheel dressing. A holder which may easily be secured to the table is supplied with the machine. It will accommodate any of the usual truing devices. The machine is designed to take a wheel 12 in. in diameter with a 7-in. or 8 in. hole. This gives a 2½ in. or 2-in. face, which is wider than is usually desirable for grinding. With the dressing outfit provided, however, it is easy to dress the wheel to give a narrower cutting face of from, say, ¾ in. to 1½ in., and still retain the advantages of the stronger

HIGH-SPEED AMMONIA COMPRESSOR.

CONSTRUCTED BY MESSRS. H. J. WEST AND CO., LIMITED, ENGINEERS, LONDON.

Fig 1.

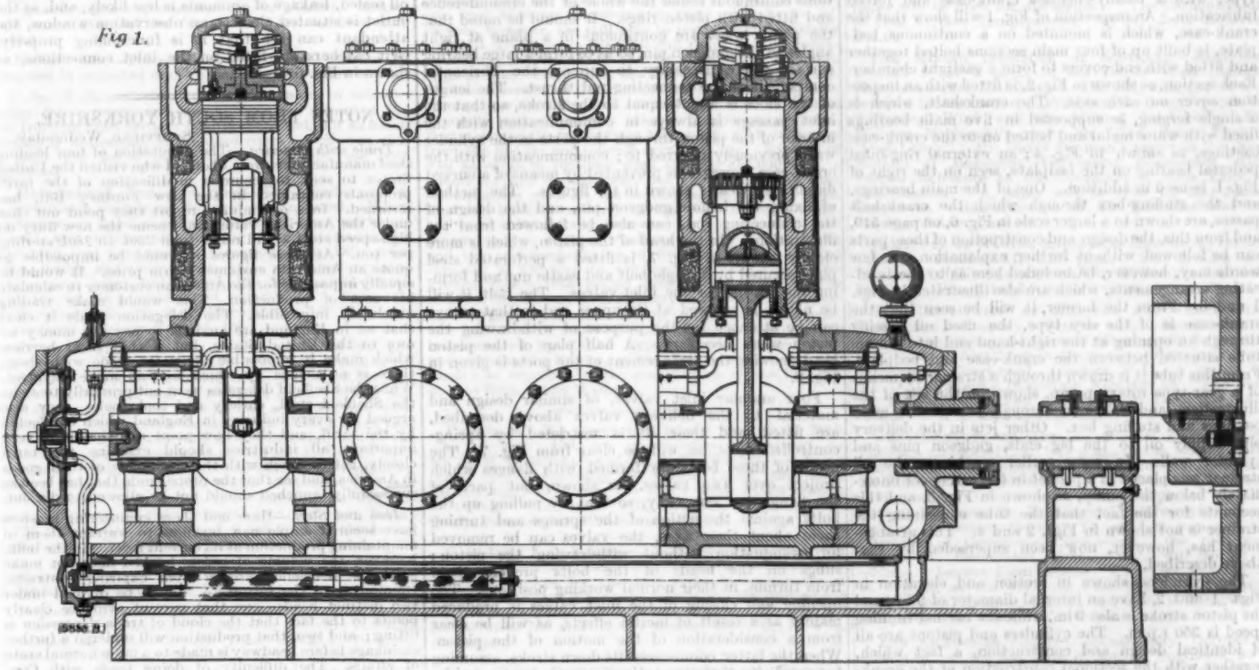


Fig.2.

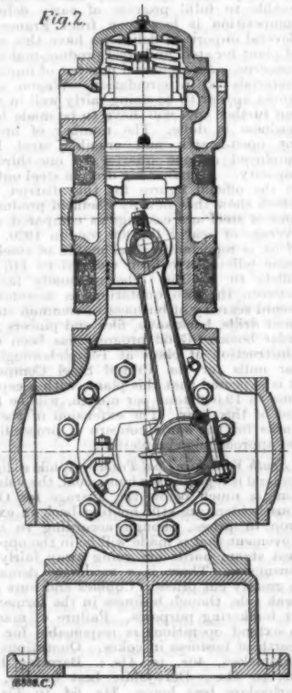


Fig.3.

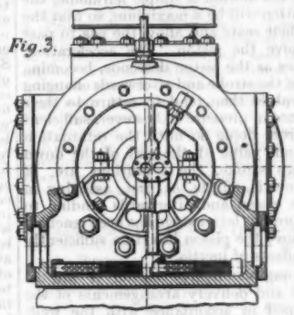
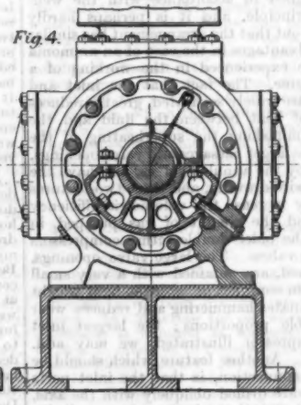


Fig.4.



wheel. The employment of a narrow cutting face in this way gives a method of varying the surface speed as shown in Figs. 4 and 5, while in cases in which this variation can be neglected the method of employing three dressings as in Fig. 4 employs the face of the wheel more fully and extends its life.

The extreme travel of the table of the machine is 16 in. and the vertical movement is from the centre of the spindle to 7 in. below it. The in and out travel is 3½ in. This motion has an index reading to $\frac{1}{1000}$ in. The faces of the iron water tank shown on the back of the machine in Fig. 2 were ground on a similar machine to that on which it is fitted. The side dimensions are 20 in. by 10 in., and in this case the splash guards had to be removed to clear the job. The working face of the table is 10 in. by 24 in. The power required to drive the grinder is from 5 h.p. to 15 h.p., depending on the work being done, and the total weight is 2,000 lb.

HIGH-SPEED AMMONIA COMPRESSOR.

ALTHOUGH the advantages to be gained from the employment of high speeds of revolution, viz., reductions in weight, space occupied and first cost, are no less with refrigerating plant than with other machinery, refrigerating engineers have been slow to adopt the principle, probably because the difficulties involved are greater than usual. Such difficulties as exist in the case of the ammonia compressor seem, however, to have been overcome, and Messrs. H. J. West and Co., Limited, of 72 and 74, Gray's Inn-road, London, W.C. 1, and Saxilby, Lincoln, have been employing such compressors in connection with their ice-making and cold-storage installations for upwards of two years with entirely satisfactory results. By the courtesy of their directors, Mr. Leuig Chew, M.I.Mech.E., and Mr. W. F. Jennings, M.I.Mech.E., who have taken out several patents in connection with these machines, we are able to illustrate on this page, and on page 510, an example of one of the firm's quick-revolution compressors which has a refrigeration capacity of 100 tons a day, and an ice-making capacity of 60 tons a day of 24 hours.

Before describing the design features of the machine, it would, perhaps, be as well to explain how the above-mentioned capacity is arrived at. The definition employed by Messrs. West is that adopted by the American Society of Refrigerating Engineers in December last, and which will probably be adopted in this country in the near future. By this definition, the heat extraction is supposed to take place at + 5 deg. F. suction temperature and to be discharged to the condensing water at 86 deg. F. A 1-ton machine would be able to produce a short ton of ice in 24 hours from water at 32 deg. F., and since the latent heat of fusion of ice at that temperature is 144 B.Th.U. per pound, the heat extracting capacity of the 100-ton machine would be 1,200,000 B.Th.U. per hour under the temperature conditions specified. We may add that the reasons for selecting the above-mentioned temperatures as standards are that both correspond reasonably well with average working conditions, and both can be converted exactly into Centigrade units, + 5 deg. F. being equal to − 15 deg. C. and 86 deg. F. being equal to 30 deg. C.

The particular installation we are about to describe has been supplied to an ice-making plant in South Africa. The machine is illustrated in Figs. 1 to 5, the latter showing that it is direct-coupled to a high-speed steam engine by Messrs. Bellis and Morcom, Limited. Similar installations have, however, been supplied direct coupled to electric motors, the floor space occupied being somewhat less in such cases. The actual floor space required by the steam-driven plant illustrated is 85 sq. ft., whereas that for a horizontal, slow-speed compressor of similar capacity, driven from the tail rod of a steam engine, would be about 385 sq. ft. This feature is obviously of considerable importance in marine installations, for which the high-speed plant is particularly well suited. The weight of the compressor and bed-plate alone, it may be added, is 7½ tons, which figure

is of the order of one-third of the weight of a slow-speed, horizontal machine of equal capacity.

From the sectional drawings of the compressor which are reproduced in Figs. 2 to 5 on page 507, it will be seen that it is of the four-cylinder, vertical, single-acting type, with a totally-enclosed crank-case and forced lubrication. An inspection of Fig. 1 will show that the crank-case, which is mounted on a continuous bedplate, is built up of four main sections bolted together and fitted with end covers to form a gastight chamber. Each section, as shown in Fig. 2, is fitted with an inspection cover on each side. The crankshaft, which is a single forging, is supported in five main bearings lined with white metal and bolted on to the crank-case castings, as shown in Fig. 4; an external ring-oiled pedestal bearing on the bedplate, seen on the right of Fig. 1, is used in addition. One of the main bearings, and the stuffing-box through which the crankshaft passes, are shown to a larger scale in Fig. 6, on page 510, and from this, the design and construction of these parts can be followed without further explanation. A few words may, however, be included here as to the lubricating arrangements, which are also illustrated in Figs. 1 and 6. From the former, it will be seen that the crank-case is of the dry type, the used oil passing through an opening at the right-hand end into a large tube situated between the crank-case and bedplate. From this tube it is drawn through a strainer by means of a gear-type rotary pump, shown on the left of the illustration, and delivered through jets to the main bearings and stuffing box. Other jets in the delivery pipe supply oil to the big ends, gudgeon pins and cylinder walls. In some earlier machines, the oil strainer was placed in a pocket in the end cover immediately below the pump, as shown in Fig. 3, and this accounts for the fact that the tube containing the strainer is not shown in Figs. 2 and 4. This arrangement has, however, now been superseded by that above described.

The cylinders, shown in section and elevation in Figs. 1 and 2, have an internal diameter of 9 in., and the piston stroke is also 9 in., while the normal running speed is 350 r.p.m. The cylinders and pistons are all of identical design and construction, a fact which, together with the sectional construction of the crank-case above referred to, considerably reduces the time and cost of manufacture. This feature enables machines of different capacities to be made up by merely employing a larger or smaller number of cylinders, the majority of the parts being taken from stock. From the illustrations it will be seen that the cylinders are cast with open ends and with an annular inlet passage in the centre communicating with the interior through ports in the cylinder wall. This part of the cylinder is lagged with heat-insulating material, while the upper portion, in which an annular delivery passage is formed, is provided with an open water jacket for cooling.

The upper portion of the cylinder is bored to a larger diameter than the working portion, and in it fits a movable head which is held in position by three strong helical springs in compression. The lower ends of these springs fit into recesses in the head, and their upper ends are pressed downwards by a cast-iron dished cover secured to the cylinder casting by means of studs. It will be readily understood that this arrangement constitutes a safety device, which serves to relieve excess of pressure arising from any accidental cause, and also to prevent any serious damage from occurring in the event of a solid foreign body getting into the cylinder. The head itself, which is shown to a larger scale in Fig. 7, on page 510, is composed of two steel forgings of which the lower one forms the seat for the delivery valves. The lower part, it will be seen, is formed with a screwed shank, and a nut on this clamps the two parts together. Two annular valves, made of a specially hard and tough steel alloy, are provided, and these valves, which are formed with lips on their working faces, cover the delivery ports in the lower portion of the cylinder head; the arrangement of these ports is shown in the half plan reproduced in Fig. 8. The valves are prevented from moving laterally by three resilient stops, one of which is shown in section on the left of Fig. 7, and their vertical lift is controlled by light steel springs surrounding the stops, as will be clear from the illustration. The necessary lift for normal working conditions is of the order of $\frac{1}{64}$ in., and vertical movement in excess of this amount is limited by the resilient stops. The compressed gas passes through the annular delivery passage to the pipe connection shown on the left of Fig. 2, and it should, perhaps, be explained that the smaller annular groove above the delivery passage is provided merely to reduce the thickness of the metal at this part; it has no connection with the working of the compressor.

Before dealing with the inlet arrangements, which we regard as the most interesting feature of the whole design, it will be necessary to examine the construction of the piston. Two longitudinal sections of this part, taken in planes at right angles, are given in Figs. 1 and 2, and from these it will be observed that it is of the trunk type with a total length considerably greater than that of the stroke. The central portions of the walls are cut away in the plane of the gudgeon pin so as to form two wide slots, above and below which are portions continuous round the whole of the circumference and fitted with piston rings. It should be noted that the piston walls are continuous in a plane at right angles to the gudgeon pin, so as to form a large bearing surface where necessary to support the horizontal component of the connecting-rod thrust. The length of the slots is about equal to the stroke, so that the inlet passage is always in communication with the interior of the piston through the ports in the cylinder walls previously referred to; communication with the crank-case, however, is prevented by means of a curved diaphragm clearly shown in the figures. The method of fixing the hollow gudgeon pin, and the design of the connecting rod, can also be followed from the illustrations. In the head of the piston, which is more clearly shown in Fig. 7, is fitted a perforated steel plate secured by a single bolt and castle nut and forming the seating for the inlet valves. The bolt, it will be noted, is screwed at its upper end so that an eye can be attached for the purpose of withdrawing the piston when necessary. A half plan of the piston head showing the arrangement of the ports is given in Fig. 9.

Four annular inlet valves, of similar design and material to the delivery valves above described, are fitted, and their lift is restricted by spring-controlled bolts, as will be clear from Fig. 7. The heads of these bolts are formed with flanges which project over two valves, as shown, but parts of the flange are cut away, so that by pulling up the bolts against the action of the springs and turning them about their axes, the valves can be removed for examination without withdrawing the piston; snugs on the heads of the bolts prevent them from turning in their normal working positions. The opening and closing of the inlet valves is produced mainly as a result of inertia effects, as will be clear from a consideration of the motion of the piston. When the latter commences its down stroke, assuming for simplicity that the motion is simple harmonic, the downward acceleration will be a maximum, so that the valves will leave their seats and allow the gas to pass into the space above the piston. The acceleration, of course, diminishes as the piston descends, becoming zero in the middle of the stroke and afterwards changing sign, so that the valves then tend to return to their seats. The difference in pressure is, however, sufficient to prevent them from doing so until the retardation reaches its maximum value at the end of the down stroke. On the up stroke, the conditions are, of course, reversed, inertia effects, at first, assisting in keeping the valves closed and afterwards tending to open them, but before this latter stage has been reached, the gas pressure above the piston has risen sufficiently to counteract the effects of inertia.

From the foregoing descriptive matter it will be seen that the inlet and delivery arrangements of the machine are designed in accordance with the well-known uniflow principle, and it is perhaps hardly necessary to point out that the arrangement has similar thermodynamic advantages in the case of an ammonia compressor as are experienced in the working of a uniflow steam engine. The fact that the inlet and delivery passages are widely separated, greatly reduces the interchange of heat between the fluid and the metal, thereby diminishing the superheating of the incoming gas. The larger passages and valve openings, rendered possible by the annular valves, also have the effect of reducing wire-drawing, and these two features together materially increase the volumetric efficiency of the machine and the weight of gas pumped, in comparison with the older double-acting compressors having mushroom valves. The large valve openings, as already mentioned, are obtained with a very small lift, and this fact, in conjunction with the light weight of the valves, eliminates hammering and reduces wear to almost negligible proportions; the largest inlet valve in the compressor illustrated, we may add, weighs only 2¼ oz. Another feature which should be mentioned in this connection, is that the inlet ports in the piston head are drilled obliquely with the axis, so that the gas flowing through them has a velocity component tangential to the valves. A slight rotary motion is thus imparted to the latter, which tends to dislodge any particles of grit present on the seating, and also to render the small amount of wear taking place quite uniform.

One other detail, which may be referred to in concluding our description, is the pressure-relief valve fitted on the delivery side of the machine. Such valves are, of course, rarely called upon to operate, and, consequently, are liable to become stuck fast with carbonised oil and dirt. For this reason, Messrs. West fit the valve on the bottom of the oil separator, and use it for returning the oil from the separator back to the crank-case, as well as for automatically relieving excess of pressure. The former operation has necessarily to be carried out daily, so that the valve is kept in proper working order. The arrangement has the additional advantages that, since the valve is oil sealed, leakage of ammonia is less likely, and, as the outlet is situated close to an observation window, the attendant can see that it is functioning properly. Grit catchers are fitted on the inlet connections, as shown in Fig. 5.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Trade with America.—The deputation of four leading steel manufacturers from Sheffield who visited the United States to seek to secure a modification of the tariff proposals contained in the new Fordney Bill, has returned. In a preliminary report they point out that under the American valuation scheme the new duty on high-speed steel would range from 250*l.* to 280*l.* sterling per ton. At these figures it would be impossible to quote an American customer a firm price. It would be equally impossible for the American customer to calculate his cost of production. This would make trading absolutely impossible. The delegation made it clear that we in England are anxious to pay the money we owe to the United States, but if they erect barriers which make it impossible for us to trade with them, there is no means by which we can make payment. While the Sheffield delegates went out primarily to assist the Sheffield steel, cutlery and tool trades, they also argued for every industry in England which is affected by the tariff, and they now point out that it is very important all industries should examine the tariff closely, get in touch with the consumers of their goods in America, and see that the propaganda that has been so successfully launched should not be allowed to die out.

Iron and Steel.—Here and there engineering masters have secured ample new business to warrant them in maintaining production at its current level. In the bulk, however, the volume of orders booked does not make good the deficiency arising from expiring contracts. Opinion as to the future appears to be divided under two distinct heads—one that current evidence clearly points to the fact that the cloud of trade depression is lifting; and two, that production will undergo a further shrinkage before headway is made to a more normal state of affairs. The difficulty of doing trade with Continental buyers in face of exchange acrobatics, is to some extent qualified by the fact that German producers are unable to fulfil promise of early delivery, and that competition is less keen from France and Belgium. Several important deliveries have this week been made of plant for steel and steel product-making to provincial concerns. An increased number of inquiries for railway materials is in circulation. Wagon and locomotive works appear to be doing fairly well in this connection, but further cuts will have to be made before really big business is done. The number of orders circulating for open-hearth and crucible steel keeps furnaces employed at one quarter to one-third their normal capacity. A further big drop in steel output is recorded in the official figures for this district just published, which show that in July Sheffield produced only 23,000 tons of steel and castings as compared with a monthly average of nearly 100,000 tons in 1920. A further cut of 5*s.* is reported in local makes of steel billets. Hard basic billets have been reduced to 11*l.* and soft basic billets to 7*l.* 15*s.* The unusually large discrepancy between the two quotations is accounted for by the record scarcity of business in common steel. Makers of twist drills, hack saws, files and pincers report depleted order books. Good progress has been made with the construction of plant at Templeborough for strip and bar mills for the United Steel Companies, Limited. It is expected that this plant, with a capacity of 13,000 tons to 19,000 tons per month, will be finished by the end of this year. The extension of the Appleby steel works for the same concern is proceeding, but is not yet approaching completion.

South Yorkshire Coal Trade.—While a slightly improved demand is reported for house coal, the volume of business done is much below the average for October. Many householders are still holding back in expectation of a drop in prices, though according to merchants any movement that is made will be in the opposite direction. Best steam hards are going away fairly well to home consumers. There is a moderate demand for export at greatly cut prices. Cobbles and nuts are still on the weak side, though business in the former is fairly good for bunkering purposes. Failure of many steel works to extend operations is responsible for the continued dearth of business in cokes. Quotations: Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire best house, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 32*s.* to 33*s.*; Derbyshire small nuts, 29*s.* to 30*s.*; Yorkshire hards, 31*s.* 6*d.* to 32*s.* 6*d.*; Derbyshire hards, 30*s.* 6*d.* to 31*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; smalls, 5*s.* 10*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is very quiet. Owing to its continued great scarcity, No. 3 G.M.B. maintains its value at 120*s.*, but the lower qualities—particularly forge, mottled and white—are very plentiful, and are purchasable at below the prices regarded as the market quotations. No. 4

foundry is offered freely at 119*s*. No. 4 forge and mottled are put at 117*s*. 6*d*., but it is difficult to ascertain on how much lower terms orders would be accepted. White iron is quoted 115*s*., but customers can buy at less.

Hematite.—In this branch increased output has made supply a good deal more than ample, with the result that recognised market quotations can be shaded. Makers still name 132*s*. 6*d*. for No. 1 and 130*s*. for Nos. 1, 2 and 3.

Foreign Ore.—There is almost entire absence of business in imported ore. Nominally best rubio is 28*s*.

Coke.—Sellers of coke are very reluctant to acknowledge fall in prices, and several firms still ask up to 35*s*. for Durham blast-furnace quality delivered, but an easier feeling is noticeable, and indeed there are reports that a good deal below the foregoing quotation has been accepted.

Manufactured Iron and Steel.—Very little new is ascertainable concerning finished iron and steel. Manufacturers are keen to secure orders, as some works are closed and others are running only intermittently. Common iron bars are 14*l*.; marked bars, 18*l*.; steel ship, bridge and tank plates, 14*l*.; steel boiler plates, 19*l*.; steel joists and angles, 13*l*. 10*s*.; steel billets, 10*l*. 10*s*. to 11*l*.; rounds and squares, 13*l*.; flats, 14*l*.; heavy steel rails, 12*l*. 10*s*.; black sheets, 15*l*. 10*s*.; and corrugated galvanised sheets, 19*l*.

Shipments of Iron and Steel.—Shipments of iron and steel from the port of Middlesbrough during September totalled 43,839 tons, 7,560 tons being pig-iron, 3,632 tons manufactured iron, and 32,647 tons steel. Of the pig-iron shipped 4,010 tons went abroad and 3,530 tons went coastwise; of the manufactured iron loaded 2,314 tons went abroad and 1,318 tons went coastwise, and of the steel cleared 28,907 tons went abroad and 3,740 tons went coastwise. Belgium was the best customer for pig-iron, taking 2,286 tons; whilst Wales received 2,120 tons and Scotland 1,060 tons. Once more India was the largest importer of manufactured iron and steel, taking 1,732 tons of the former and 9,288 tons of the latter. Other principal importers of steel were: Nigeria, 3,782 tons; New Zealand, 3,082 tons; Portuguese East Africa, 2,918 tons; Cape Colony, 2,439 tons; Argentine, 2,316 tons; and Australia, 1,228 tons.

Imports of Iron and Steel.—Interesting returns issued by the Tees Conservancy Commission give iron and steel imported to Middlesbrough from Holland, Belgium, France, Norway and Germany for the eleven months ending September 30 last, as compared with the corresponding periods of 1912–13 and 1913–14. The quantity of pig-iron brought to the Tees from those countries during the past eleven months reached 57,783 tons, against 1,088 tons in the period 1912–13, and 1,427 tons in 1913–14. September imports of pig-iron were the largest on record, amounting to 20,320 tons as compared with 12,302 tons in August, the previous heaviest being 7,920 tons in July. Billets, blooms and slabs unloaded during the eleven months just ended are returned at 28,323 tons, against 38,667 tons in 1912–13 and 33,655 tons in 1913–14. Plates, bars, angles, rails, sheets, and joists unshipped during the past eleven months amounted to 20,191 tons, against 22,023 tons in 1912–13 and 19,481 tons in 1913–14.

Forge and Mill Wages.—The accountants to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England certify the average net selling price of bars and angles for the two months ending August 31 last at 16*l*. 13*s*. 4·77*d*. per ton, as compared with 19*l*. 3*s*. 8·19*d*. per ton for the previous two months. On these figures the sliding scale gives a reduction of 25 per cent. on puddling and other forge and mill wages. The reduction takes effect from the 26th ultimo. Since the beginning of the year wages have fallen by 132½ per cent. and they now stand at 97½ per cent. above the standard.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—An unique situation has arisen in the South Wales coal trade as a result of the dispute in respect to wages. Sir William Plender, as independent chairman of the National Coal Board, was asked whether the aggregate net profits realised by the coal owners in July and August on the district ascertainments, were to be taken into account in fixing the October wages of the colliery workers. Sir William decided that they were, and on the strength of this the Welsh miners reckon they are entitled to 112·81 per cent. on the standard rates of 1915. The coal owners, however, state that the July profits were absorbed in the September wages, and on this contention offered the men, at a meeting of the South Wales Coal Board, held on Monday, 51·68 per cent. on the 1915 standard. This the men refused. The result is that the owners are not aware of their wages costs for October and neither do the men definitely know what they are to receive for their labour in the present month. The whole matter is to be considered at a meeting of the National Board which will probably be held next week, as other coalfields are involved. The crux of the difficulty lies in the fact that the national strike agreement does not provide for any maximum reduction in wages in October, whereas for the three months' period, in which the 10,000,000*l*. subsidy was available, it was provided that the maximum reduction in July should be 2*s*. per day, 2*s*. 6*d*. in August and 3*s*. in September. The only stipulation for October is that "in no district shall wages paid be at lower rates than the standard wages plus 20 per cent.," and it is on this contention that the owners' offer of 51·68 per cent. was made. The dispute between the Welsh coal owners and the Mines Department as to whether the former are liable for 72·6 per cent. on the 1915 standard rates for wages in September or 97·57 per cent., has not yet been settled, though Sir William Plender has been asked to give his interpretation on the question. In the meantime, business on the coal market is held in abeyance. Many collieries are stopped, and those comfortably stemmed over the next week or so are refusing to entertain fresh business or putting up their prices by 2*s*. 6*d*. Buyers, however, are still able to secure best Admiralty and best dry large at 30*s*., the full range of Monmouthshire large at 27*s*. 6*d*. to 28*s*. 6*d*., and No. 2 Rhondda large at 26*s*. Sized coals are scarce and steady at 30*s*. for steam nuts and 35*s*. for dry nuts. Smalls of most descriptions are tight, and some sellers refuse to dispose of small without buyers take a proportion of large. Best steam smalls realise from 19*s*. to 20*s*., with ordinaries from 16*s*. to 18*s*., and inferior drys from 10*s*. Exports of coal as cargo in the past week totalled 462,000 tons, a record for this or last year, but 80,000 tons less than the shipment made in the corresponding week of 1913. The coal loading capacity of the Bute Docks, Cardiff, has been substantially increased by the completion of repairs to two railway viaducts leading to the docks and the re-commissioning of five tips with a loading capacity of 300 tons to 400 tons per hour each. The French Marine has placed contracts for the supply of about 50,000 tons of Admiralty large coal and 150,000 tons of patent fuel, delivery up to the end of the year. The fuel is to be made in France and the business has been secured by Cardiff exporters with patent fuel-making plant in France, so that it is expected that the small coal required for the manufacture of the fuel will be sent from South Wales.

PERSONAL.—We regret that in our issue of the 30th ult., on page 475, we stated that subsequent to Mr. H. H. G. Mitchell and Mr. A. G. Vaughan-Lee being taken into partnership by Messrs. Coode, Matthews, Fitzmaurice and Wilson, the firm's name would remain as before. The name will, however, henceforth be Coode, Fitzmaurice, Wilson and Mitchell.

CAST-IRON PIPE PRICES.—The Staveley Coal and Iron Company, Limited, Chesterfield, state that in future they will quote prices for cast-iron pipes independently of any association or other pipe founders. We understand that this company has recently considerably extended its facilities for making the smaller sizes, up to 4 in. diameter.

THE CIVIL ENGINEERS' APPOINTMENTS BOARD.—Inquiries are invited by this Board (whose offices are at 8, Princes-street, Westminster, London, S.W. 1) from employers requiring the services of professional engineers or professional engineering assistants. The Board's register of those seeking professional engineering appointments is open to all whose training, qualifications and experience have been approved by the Institution of Civil Engineers, by election to corporate membership or admission to studentship of that body. The Board will also be glad to be informed of vacancies which corporate members of the Institution of Civil Engineers may have from time to time for pupils or apprentices, or for assistants under agreement.

GRAPHITISATION IN CAST-IRON.—Microscopic study of graphitisation in cast-iron has been further studied by the Bureau of Standards, Washington, states *The Iron Age*, New York, and the investigation supplements that reported in the technologic paper, No. 129. After prolonged annealing, considerable graphitisation occurs in the material below the thermal critical range, approximately 700 deg. C. Below 500 deg. C., however, no change was detected, even after a prolonged heating period. In the low-temperature graphitisation, only the pearlite is affected; the free carbide does not appear to be changed until the thermal critical point has been passed and the solution of this constituent has begun. The form in which the graphite exists after annealing depends upon the initial structural state of the iron. If any flakes of graphite exist, they act as nuclei for the deposition of the graphite formed during annealing; if no such flakes are present, the new graphite takes the form of small globules rather than flakes.

METALLIC RESISTANCE MATERIALS.—A British standard specification for metallic resistance materials for electrical purposes (No. 115, 1921) has just been issued by the British Engineering Standards Association. For the purposes of this specification metallic resistance materials have been divided into the following five classes: (A) Materials for use when a low-temperature coefficient is required at temperatures not exceeding 60 deg. C. (such as in standard resistances and in sub-standard instruments). (B) For use when the temperature coefficient may vary more than that permitted for Class A, and at temperatures not exceeding 200 deg. C. (such as in instruments other than sub-standard). (C) For use when the temperature coefficient may vary over a wide range and at temperatures not exceeding 300 deg. C. (D) For use at high temperatures not exceeding 700 deg. C. (as in heating apparatus). (E) For use at high temperatures not exceeding 1,000 deg. C. (as in heating apparatus). It is specified that the value of the resistivity of any material shall not differ from the value declared by the makers by more than 5 per cent., and as uniformity of resistance and dimension are matters of considerable importance, the specification fixes limits for these. A comprehensive list of standard sizes of wires, tapes and sheets is given. Copies of the specification may be obtained from the Secretary, British Engineering Standards Association, 28, Victoria-street, S.W. 1, price 1*s*. net, post free 1*s*. 2*d*.

NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING ENGINEERS.—Saturday, October 8, at 2 p.m., in the Wood Memorial Hall, Newcastle-on-Tyne, the president, Mr. C. C. Leach, will deliver his address. The following paper will be open for discussion: "The Carbonisation of Coal at Low Temperatures," by Mr. John Roberts, D.I.C.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, October 8, at 3 p.m., in the Heriot Watt College, Chambers-street, Edinburgh. The following papers will be open for discussion: Professor H. Brigg's paper on "Physical Work and the Human Machine"; Mr. William McNaught's paper on "The Beam Electric Head-Lamp"; Mr. David Penman's paper on "A New Method of Measuring Ventilating Resistances, with Special Reference to the Operation of Mine Fans in Combination." A paper will be read by Mr. James Cooper on "Measurements of Air Velocities and the Testing of Anemometers."

INSTITUTE OF MARINE ENGINEERS (INCORPORATED).—Tuesday, October 11, 6.30 p.m., "The Mining and Treatment of Tin Ore in China," by W. Semple, Associate Member. Illustrated by lantern views.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—Tuesday, October 11, commencing at 7 p.m., the Autumnal General Meeting will be held at the Young Men's Christian Association (Drawing Room), Tottenham Court-road, London, W.C. A paper by Mr. G. L. Copping (Associate Member) on "The Need for Standardising Fan Capacities at Total or Static Heads" will be read and discussed.

THE INSTITUTE OF METALS.—*Scottish Local Section*: Tuesday, October 11, at 7.30 p.m., in the Rooms of the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow, the chairman, Professor J. H. Andrew, D.Sc., will deliver an address on "Modern Aspects of Scientific Metallurgy." *Birmingham Local Section*: Tuesday, October 11, at 7.30 p.m., in the Chamber of Commerce, New-street; the chairman, Mr. H. W. Brownsdon, M.Sc., Ph.D., will deliver an address. *London Local Section*: Thursday, October 13, at 8 p.m., at the Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C. 3; Mr. O. F. Hudson, D.Sc., will deliver the Chairman's Address.

THE NEWCOMEN SOCIETY.—Wednesday, October 12, at 5 p.m., at the Institute of Marine Engineers, 85 to 88, Minories, E. 1, when a paper will be presented by Mr. G. F. Zimmer, A.M.Inst.C.E., Member, on the "History of Continuous Conveying Devices."

THE ASSOCIATION OF ENGINEERS IN CHARGE.—Wednesday, October 12, at St. Bride's Institute, Bride-lane, E.C., opening of the 1921–22 session, when the president, Captain H. Riall Sankey, C.B., C.B.E., will deliver an address entitled "Some recent Advances in Wireless Telegraphy."

THE ROYAL SANITARY INSTITUTE.—Wednesday, October 12, at 4 p.m., at 90, Buckingham Palace-road, London, S.W. 1, when a discussion will take place on "Plumbing and Sanitation on Board Ship." The chair will be taken by Sir Henry Tanner, C.B., I.S.O., F.R.I.B.A. (Deputy Chairman of Council).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 14, at 8 p.m., at Caxton Hall, paper on "Electric Cranes," by Mr. C. H. Woodfield, M.I.Mech.E., Member.

INSTITUTE OF METALS: ERRATUM.—By a slip, in Mr. H. B. Week's remarks, reproduced on page 484 *ante*, on Dr. Hanson and Miss Gaylor's paper on "Aluminium Alloys with Magnesium and Silicon," at the Institute of Metals at Birmingham, the name of Wilm was incorrectly given throughout as Wilson. The error is in the first paragraph of the third column of the page referred to.

THE BIBLIOGRAPHY OF LUBRICANTS.—The Department of Scientific and Industrial Research announce that the "Bibliography of Lubricants" compiled by the Lubricants and Lubrication Inquiry Committee has been deposited in the library of the department, at 16 to 18, Old Queen-street, Westminster, S.W. 1, and is available for reference. Owing to the expense which would be involved it is not possible to print this bibliography as originally intended. The bibliography is divided into two main parts, the papers being classified according to authors and to subjects. The references themselves are divided into two sections, one dealing with the chemical, the other with the engineering and physical aspects of the subject.

MOTORS AND TAXATION.—A return from the Ministry of Transport states that the numbers of licences current on August 31 this year were as follows:—Cars taxed on horse-power, 242,500; motor cycles, 373,200; invalid vehicles, 312; commercial goods vehicles, 128,200; road locomotives, &c., 2,650; motor ploughs, &c., 13,000; motor tractors, &c., 1,520; motor hackneys, 82,800; tramcars, 15,200; general identification marks, 11,400—giving a grand total of 870,782 motor licences. The revenue from these licences was 9,276,628*l*., of which 3,981,000 was derived from cars taxed on horse-power, 875,700*l*. from motor cycles, 2,639,300*l*. from commercial goods vehicles, 1,593,500*l*. from motor hackneys, 65,100*l*. from road locomotives, &c., 23,200*l*. from motor tractors, &c., and 11,400*l*. from tramcars. For horse-drawn vehicles, public and private, the licences in force numbered 255,500, bringing in a revenue of 201,100*l*.

HIGH-SPEED AMMONIA COMPRESSOR.

CONSTRUCTED BY MESSRS. H. J. WEST AND CO., LIMITED, ENGINEERS, LONDON.

(*For Description, see Page 507.*)

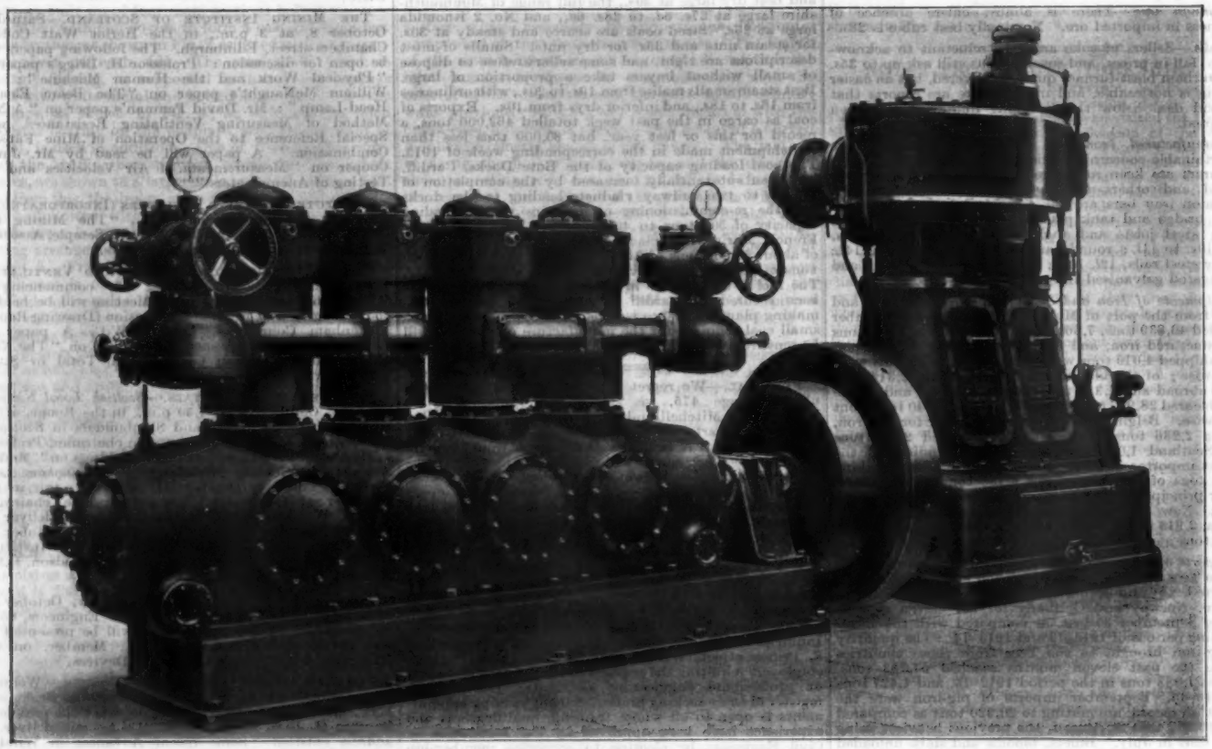
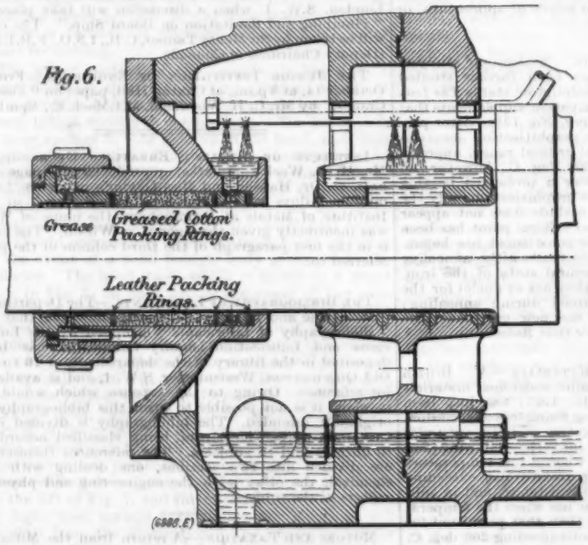
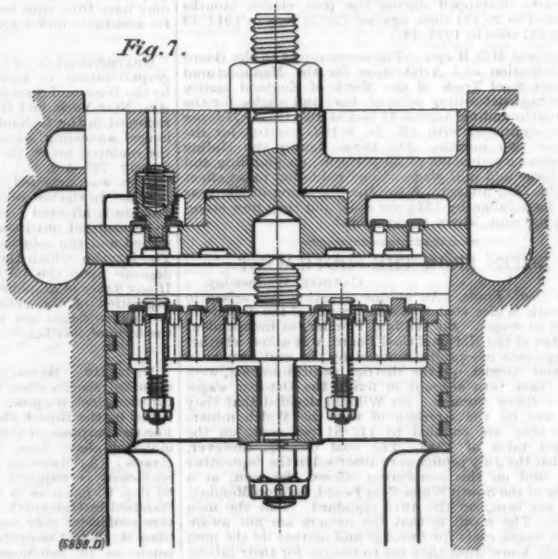
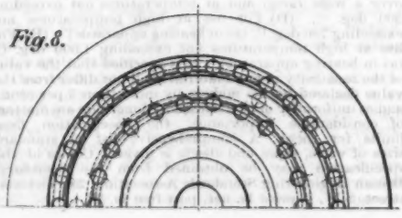


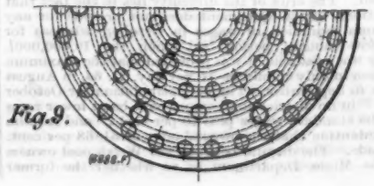
Fig. 5.





The Industrial League.—The winter sessional programme of the Industrial League was opened on Wednesday with a lecture at the Caxton Hall, Westminster, by Mr. E. J. P. Benn, C.B.E., who spoke on the "Capitalistic System." On the 12th inst., Mr. Charles Jesson, M.P., will lecture on the "Importance to the Worker of Initiative and Enterprise." The lectures will be given weekly, and among others on the programme we note Mr. E. W. Petter is down for October 19 with the subject, "Economic Axioms of Industry." Later lectures include: "Profit-Sharing and the Coal Settlement;" "Ability as a Factor in the Production of Wealth," "Cost of Living and its Implications," "Trade Boards," and so on, not excluding, of course, unemployment, industrial unrest and cognate topics.





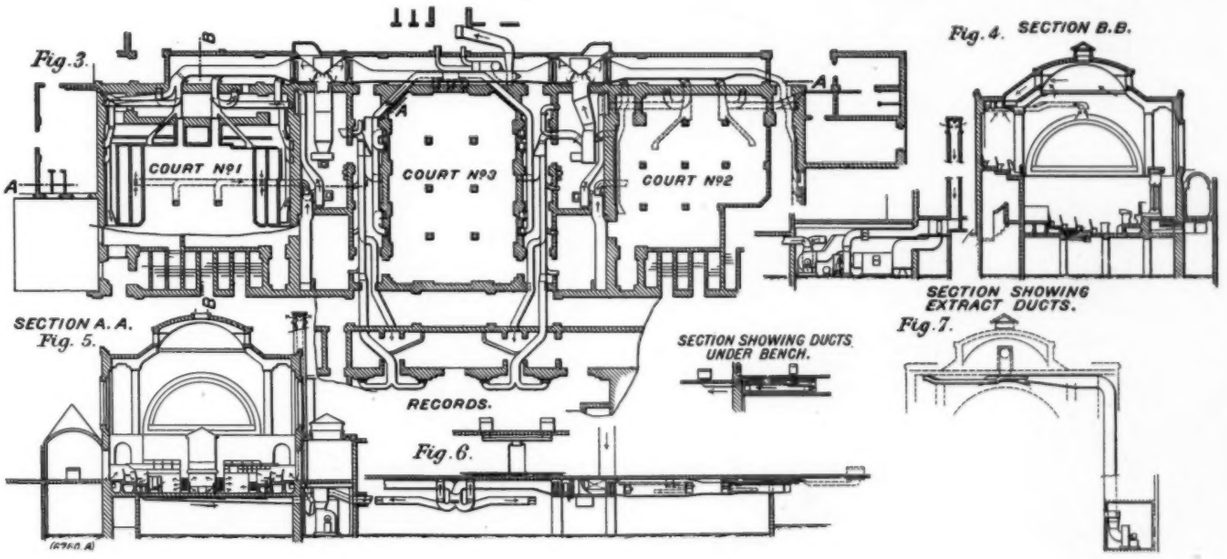
NEW COURT HOUSE FOR THE LONDON QUARTER SESSIONS.

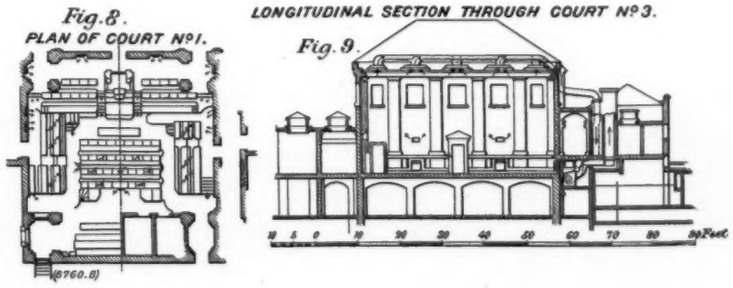
MR. W. E. RILEY, F.R.I.B.A., M.INST.C.E., SUPERINTENDING ARCHITECT TO THE LONDON COUNTY COUNCIL.

(*For Description, see Page* 518.)

Fig. 1. Interior of Court No. 1.

Fig. 2. Interior of Court No. 1.





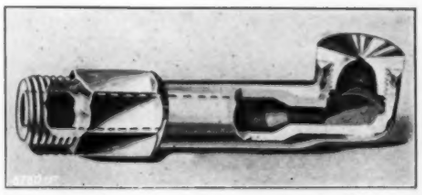


Fig. 10. Spraying Nozzle.

(*To face page* 518.)

AIR-CONDITIONING PLANT AT THE NEW COURT HOUSE FOR THE LONDON QUARTER SESSIONS.

MESSRS. THE BUFFALO FORGE COMPANY, LIMITED, ENGINEERS, LONDON.

(*For Description, see Page* 518.)

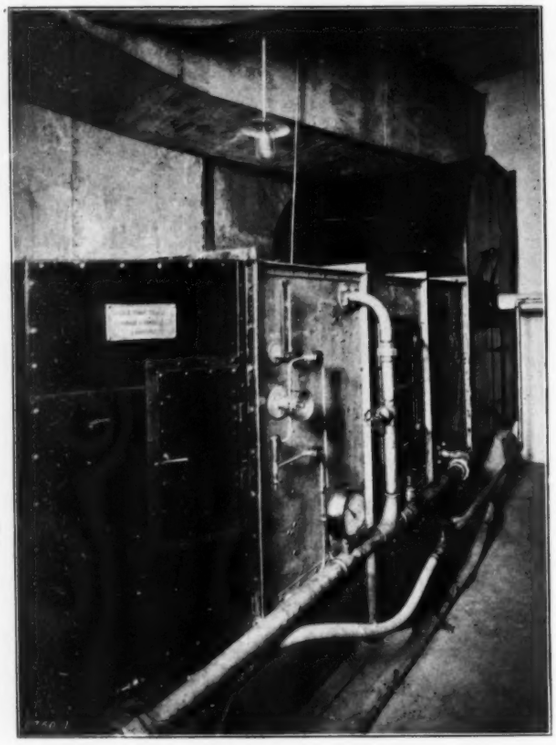


Fig. 11. View of Plant, showing Spraying Chamber.

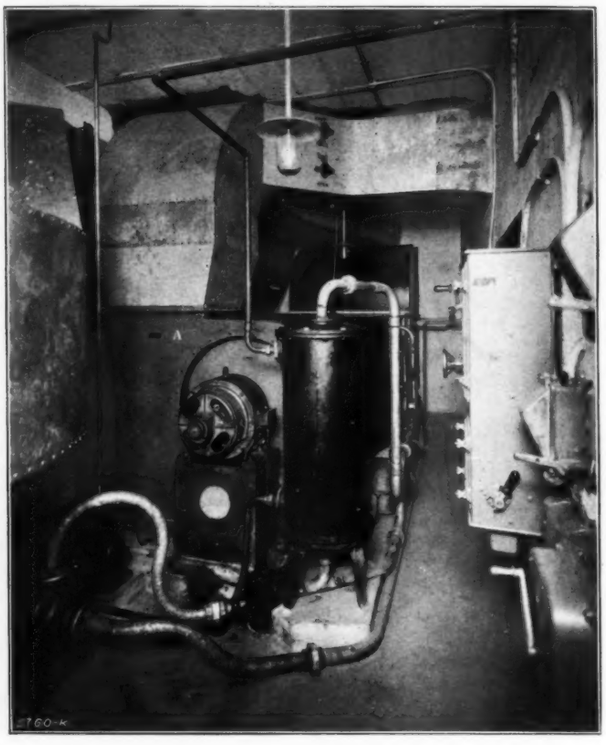
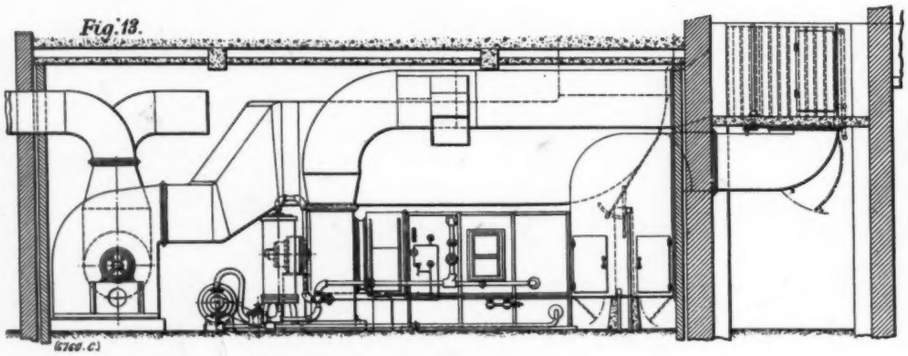
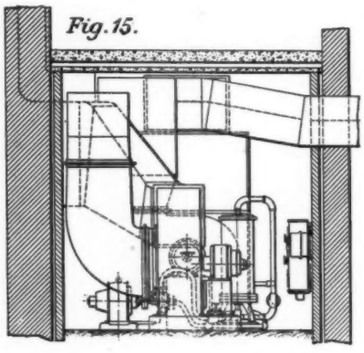
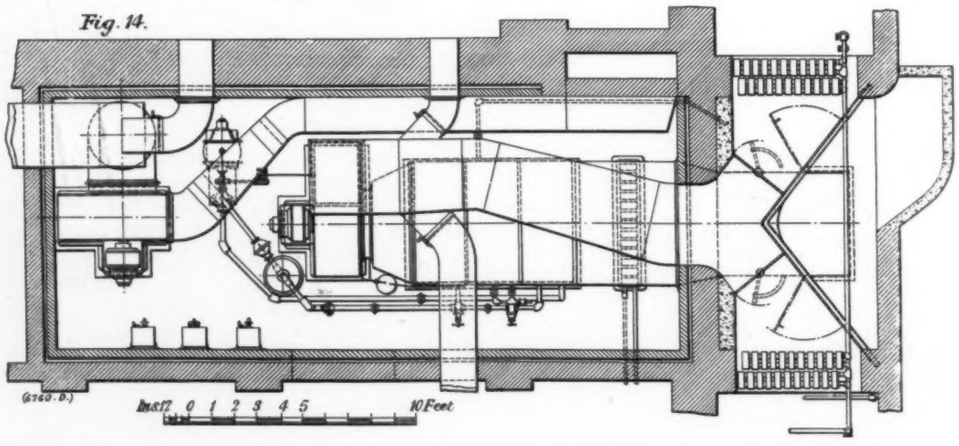


Fig. 12. View of Plant showing Water-Heater.







THE CONSTITUTION AND AGE-HARDENING OF ALLOYS OF ALUMINIUM.

(*For Description see Page* 519.)

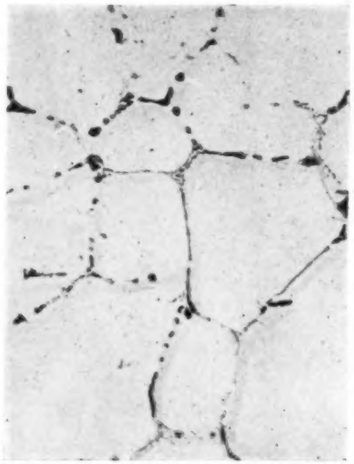


FIG. 14. $M_{1\cdot7}\,S_{1\cdot0}$ COOLING CURVE INGOT. × 150. UNETCHED.

FIG. 15. $M_{3\cdot4}\,S_{2\cdot0}$ COOLING CURVE INGOT. × 150. UNETCHED.

FIG. 16. $M_{6\cdot8}\,S_{4\cdot0}$ COOLING CURVE INGOT. × 150. UNETCHED.

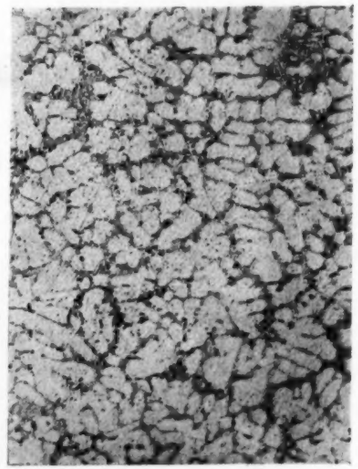


FIG. 17. $M_5\,S_2$ CHILL CAST. × 150. ETCH 10 PER CENT. ALCOHOLIC HNO_3.

FIG. 18. $M_{10}\,S_2$ CHILL CAST. × 150. ETCH 10 PER CENT. ALCOHOLIC HNO_3.

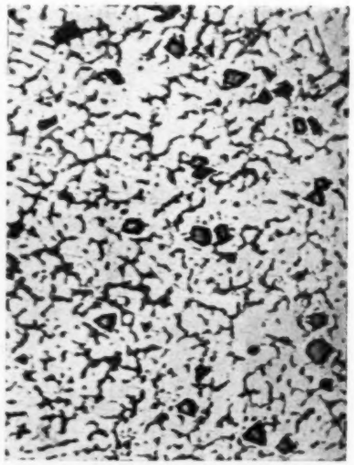


FIG. 19. $M_{20}\,S_2$ CHILL CAST. × 200. ETCH 10 PER CENT. ALCOHOLIC HNO_3.

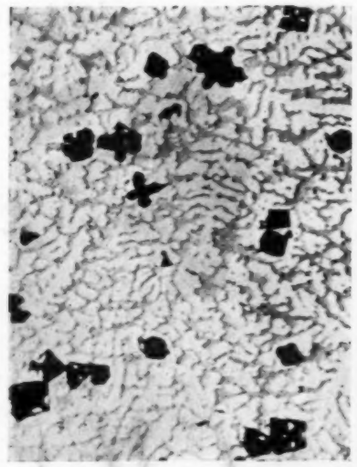


FIG. 20. $M_{25}\,S_2$ CHILL CAST. × 200. ETCH 10 PER CENT. ALCOHOLIC HNO_3.

FIG. 21. $M_{35}\,S_2$ CHILL CAST. × 200. ETCH 10 PER CENT. ALCOHOLIC HNO_3.

THE CONSTITUTION AND AGE-HARDENING OF ALLOYS OF ALUMINIUM.

(*For Description, see Page* 519.)

FIG. 22. $M_5 S_4$ COOLING CURVE INGOT. × 150. UNETCHED.

FIG. 23. $M_{10} S_4$ COOLING CURVE INGOT. × 150. UNETCHED.

FIG. 24. $M_5 S_8$ COOLING CURVE INGOT. × 150. UNETCHED.

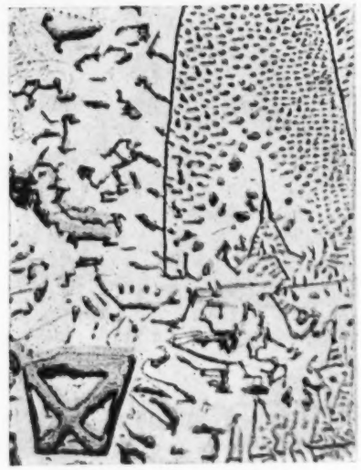


FIG. 25. $M_{10} S_8$ COOLING CURVE INGOT. × 150. UNETCHED.

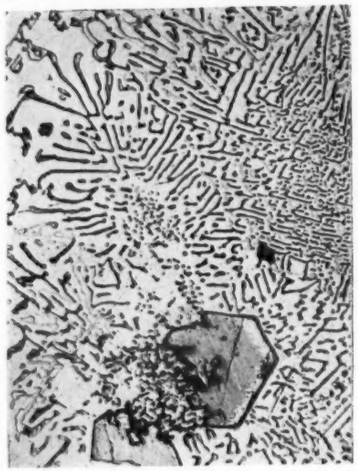


FIG. 26. $M_{15} S_8$ CHILL CAST. × 150. UNETCHED.

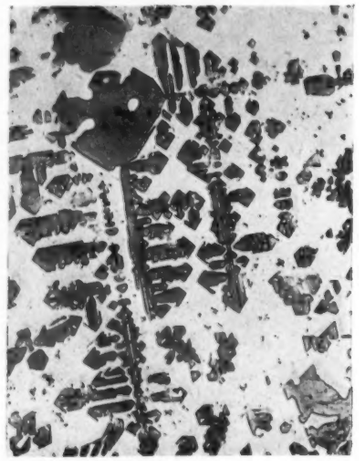


FIG. 27. $M_{35} S_{10}$ CHILL CAST. × 150. UNETCHED.

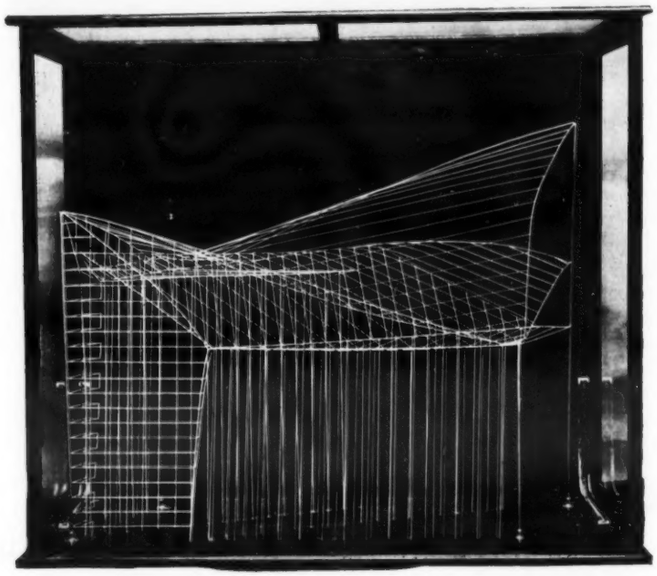


FIG. 28.

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TELEPHONE NUMBERS—3663 and 8398 GERRARD

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 509.

ENGINEERING.

FRIDAY, OCTOBER 7, 1921.

INDUSTRIAL DEPRESSION AND A COAL SUBSIDY.

THE present stagnation of industry is on such a world-wide scale that its very magnitude seems to have paralysed the minds of those from whom one might have reasonably expected some practical suggestions for its alleviation. At any rate, suggestions of any kind have been remarkably few. The chairman of one of the greatest industrial combinations in the kingdom indicated in a recent speech that, in his opinion, the collapse of the foreign exchanges was the most serious factor in the economic situation, and that it was vitally important in the interests of our trade that the exchange question should be dealt with. On the other hand, one of the most level-headed and experienced representatives of labour declared that excessive taxation was at the root of our difficulties and that some lightening of the tax-burden on industry was the first essential. It was noticeable that neither of these men, each an authority in his own particular sphere, ventured even to hint at any remedy for the present state of affairs. Normal trade can only be obtained under normal conditions, and as overwhelming taxation and the waste-paper value of much of the Continental currency are both abnormal conditions, it is easy to agree that both these matters must be rectified before trade can resume its natural course. Hence we need not concern ourselves with the question of which speaker was correct. Each emphasised the symptom which struck him as most dangerous to our industrial health and believed that if it could be made to disappear all would be well. The best way to suppress symptoms is, however, to cure the disease, as otherwise they will reappear in other forms equally malignant.

The fundamental cause of the dislocation of industry is the want of confidence existing in the world, between nation and nation, between parties in the State, and between employers and employed. National, and therefore individual, wealth has been destroyed on a prodigious scale, and those who possess what remains are unwilling to invest it in industry because of the uncertainty of the outlook. The Russian peasant refused to grow wheat because he found that under his form of government he could not be sure of reaping where he had sown. The immediate symptom of his want of confidence was the famine and destitution now ravaging the country. During the boom period, not very many months ago, the British manufacturer lost innumerable orders by refusing to quote a fixed price or firm delivery, neither of which he felt able to do because he had no confidence in the stability of industrial conditions. The Continental buyer, even to-day, hardly dares to place a large order in this country, because he has no security that what he would pay 1,000 marks or francs for at the present rate of exchange might not cost him 50 per cent. more when the time for payment comes. International trading has become largely a matter of gambling on the foreign exchange rate, with a spice of uncertainty as to whether payment will be made at all. Banks hesitate to finance such transactions, and are indeed chary of risking their depositors' money in any kind of trade or manufacture because of want of confidence in international, political or industrial matters. These are the plain facts of the situation, and as and when general confidence is restored, so the symptoms will simultaneously disappear.

Confidence, however, is a plant of slow growth and a considerable time must elapse before it is re-established. Meanwhile the situation has got to be faced, and any suggestion for easing it is worthy of consideration. Sir Leo Chiozza Money, whose weekly utterances in *The Observer* on economic questions are no doubt taken seriously by some people, proposes a subsidy on industrial coal. "Cheap coal," he says, "the life-blood of British industry, is impossible unless we call on the mine-owner to work at a loss and upon the miner to do arduous and dangerous work for a living worse than we should care to offer a work-house inmate." Starting from so preposterous a statement of course any conclusion may be drawn. The author of it, if he knows anything at all about the coal industry, must know perfectly well that the output of coal per man employed in the mines fell steadily for years before the war, and that its fall occurred simultaneously with rises in the miners' wages. He must also know that it is shamefully less than in other countries, and that even if we could only revert to the comparatively low rate of output obtainable in 1913, coal would be vastly cheaper to-day than it is. A reference to Lord Weir's presidential address to the Junior Institution of Engineers last year will throw a most interesting light on the principal cause why coal is dear, and it is simply absurd for Sir Leo Chiozza Money, or any other would-be political economist, to pretend that cheaper coal is incompatible both with a reasonable return on the capital spent in developing the mines and with a proper standard of living for the miner.

In order to be absolutely fair to the author of the latest scheme for re-habilitating our economic life, we will quote his proposal in his own words. "A subsidy confined to industrial coal is indicated. If of suitable proportions, it would quickly bring our blast furnaces into action and revive every industry by cheap power. . . . It would cheapen electric current just as it would cheapen bricks and steel ingots. It would revive every activity of the nation. . . . The suggested coal subsidy would be a manure for industry which would bring not only profits to masters and men, but taxable income to the Treasury. Therefore, like good manure to the scientific farmer, it would represent not monetary loss to the Government but Treasury gain; not more but less need to tax. . . . If the subsidy had the desired effect, the bounty would be payable on some 120 million tons. The amount of the subsidy is for discussion. If it were 7*s.* 6*d.* per ton, the cost would rise to 45,000,000*l.* a year, if such a consumption were realised. A smaller bounty on coal exports is also worth practical consideration."

One really hardly knows how to deal seriously with such an argument. It is based on the utter fallacy that coal cannot be produced sufficiently cheaply for industrial purposes without both bankrupting the coal owner and sweating the miner. We have already given this statement all the consideration it deserves. Were it even approximately true, Great Britain, as a manufacturing country, would have to put up her shutters for ever, and no subsidy on earth could save her. There is no more justification for subsidising coal than for subsidising the cotton, woollen, agricultural, shipping, or any other industry in the country. All are in a bad way, and every penny presented to one of them is taken out of the pockets of the others. The idea that the proposed subsidy would cost nothing at all to anybody is obviously firmly believed by Sir L. C. Money. The paragraph in his article in which this consoling idea is put forward is headed "A subsidy without cost," and contains the italicised statement "*if the manure is effective in increasing production it costs less than nothing.*" Surely if subsidies reduce the price of articles at a cost of nothing, or less than nothing, to the nation, it would be a good policy to subsidise everything. And to limit the coal subsidy to 45,000,000*l.* would be folly. If it were made ten times this figure coal could be supplied free, and on the argument of Sir Leo Money, our taxation would be at the same time enormously reduced.

The idea that a subsidy is something analogous to manure is an intriguing one, particularly as manure is, in general, of a stercoraceous nature. Subsidies are distasteful to the public, who, in spite of Sir Leo Money, have to find the money for them, and they are unfair to every industry which does not benefit by them. To propose, as our economist does, a bounty on export coal is surely to pile Pelion on Ossa. It means neither more nor less

than a demand that the British taxpayer, groaning beneath an overwhelming burden, shall make a present of some shillings a ton to every foreigner who is good enough to buy coal. The foreign purchaser needs industrial coal for one purpose only, namely, to manufacture goods to compete with our own industries. To cheapen the price he has to pay for his fuel by a subsidy extracted from our own pockets would give him a double advantage in his competition with us for what little work there is to be obtained in the markets of the world.

Earlier in the article to which we have referred, the author reminds his readers that he had previously pointed out "that it was essential to write off the unjust and maleficent war debts . . . . as much for our own sake as for the general good of the world," the inference being that writing off these debts would hasten the return of better trade. It is the trick known to logicians as *petitio principii* to call a thing unjust and maleficent because the writer does not like it. A debt between nations is no more unjust and maleficent than one between individuals, and national credit, like private honour, demands that it shall be liquidated. We might be very pleased if our creditors made us a present of the sums we owe them, but how much better would our trade be if we remitted the sums owing to us? The debtor nation could then "buy" goods from us, certainly, but when we had shipped them, we should be exactly where we are now, except for the fact that we should have made and delivered several million pounds' worth of goods for nothing. There is no escape from this conclusion. The fact that the debtor country cannot meet its obligations at once is a certain proof that it could not pay for fresh goods if these obligations were remitted. It might therefore just as well continue to owe us for material already supplied, as to owe us for a fresh consignment of goods, which we should have in reality to manufacture for nothing.

Just now, when economic questions are so pressing, and a right understanding of the factors which affect national prosperity is so important, it is a serious matter that false economic doctrines should be preached to the public. There is unfortunately nothing to prevent any writer from posing as an economist no matter how little he may know concerning trade or how defective his logical powers. Statements sufficiently dogmatic, especially if covered with a thin veneer of plausibility, always find a section of the public ready to accept them in preference to thinking for themselves. One recalls the old lament "The prophets prophesy falsely; the people love to have it so, but what will ye do in the end thereof." There is, however, some consolation in the thought that the false doctrine of subsidising the coal industry, whether for home consumption or export, will not find many adherents when once it is realised who pays the subsidy, and as for the wholesale remission of international debt, this could benefit only those nations whose debts are greater than their credits, and is not likely to be agreed to by the creditor country. An agreement for the temporary deferment of interest payments by a country which is in economic difficulties is another matter, as it lets the debtor utilise the money which otherwise would have to be sent out of the country. It is analogous to the practice or giving a trader time to meet his obligations rather than putting him through the bankruptcy court, of pressing him so hard for interest due, that the ultimate recovery of the principal is jeopardised.

THE RADIATION THEORY OF CHEMICAL ACTION AND CATALYSIS.

The discussion of the "Radiation Theory of Chemical Action," to which the Faraday Society devoted the afternoon and evening of September 28, more than maintained the high tone of these discussions. The lecture hall of the Institution of Electrical Engineers, in which the meeting took place, was well filled till a late hour. Chemical reactions are broadly distinguished as homogeneous, when all the reactants and resultant products are of the same phase, *e.g.*, when they are all gases or all miscible liquids; and as heterogeneous when those substances are not all of the same phase. The distinction was observed in the discussion which referred particularly to catalytic influences, homogeneous reactions being discussed in the afternoon, and heterogeneous reactions in the evening.

The first main subject was introduced by Professor J. Perrin, of Paris, one of the foremost investigators of the Radiation Theory of Chemical Reaction. The difficulties of that theory, which makes radiations one of the chief sources of reactions are essentially quantitative, and Professor Perrin hence at once dived into the quantum theory and into mathematics. Professor W. Mc.C. Lewis, of Liverpool, who followed him, dealt with three critical objections to the theory. In the first place, he pointed out, the rate of supply of radiant energy was often considered quite insufficient to account for the observed rate of chemical reaction; but it was overlooked that the original amount of energy of a frequency which the matter could absorb was not the only source of supply, because conversion of types of energy took place by reflection, absorption and emission between the oscillators in the system and the surroundings. Secondly and conversely, some reactions like the inversion of sugar solutions in water were not sensibly accelerated by radiations, though they should be; that was a matter of experimental arrangement, however, because even a very thin layer of water would absorb the radiations which therefore could not penetrate into the solution below; moreover we should distinguish between heat radiation in all directions, and directed light radiations. Thirdly, the absorption bands of substances examined did not always appear to be in the positions where we should look for them. Professor F. A. Lindemann, of Oxford, upon whom the President of the Society, Professor A. W. Porter, called next, did not see how the molecule was to know whether the radiation was directed or not; he showed mathematically how some of professor Perrin's difficulties might be solved.

Professor E. C. C. Baly, also of Liverpool, discussed the apparent deviations from Einstein's law of equivalence—the number of quanta observed should be equal to the number of reacting molecules—with respect to the reaction between hydrogen H and chlorine Cl which combine to HCl under the action of light. He had found that the velocity of this photochemical reaction was at first small, but subsequently increased, finally taking place at an explosive rate when the light was intense. Such increase in the rate of action was due to the reabsorption by the reactant molecules of the energy emitted by resultant molecules. It was significant in this connection that the expansion, which accompanied the reaction, was proportional, not to the intensity of the light, but to the rate of the reaction, and so was due, as experiments proved, to the ultraviolet rays, and not to the infra red.

Moreover, Daniels and Johnstone had quite recently proved that the active radiations might be absorbed, not by the reactants themselves, but by the photocatalyst. Thus some of the objections could certainly be met. Dr. Irving Langmuir, of Schenectady, who spoke after some remarks by Professor Svante Arrhenius, seemed to object that undue preference was given to radiations. Many properties, vapour pressure, solubility, electric conductivity, &c., varied with the absolute temperature; they were all quantum reactions, why single out radiations? But there are, of course, good reasons for that, the convenience of the study of photochemical reactions being one of them.

The second subject, Heterogeneous Reactions, was by its opener, Dr. Langmuir, limited to the most interesting case of "Chemical Reactions on Surfaces" and was treated more on mechanical lines. The velocity of heterogeneous reactions is governed by the law of mass action, *i.e.*, it is proportional to the concentration of the constituents. The velocity depends also upon the rate of diffusion and in the presence of solid surfaces upon the peculiarities of the films adsorbed by such surfaces. According to Nernst, Bodenstein and Fink, the film thickness should vary with the partial pressure of the gas; that seemed to account for the catalytic effect of platinum on the SO_3 in the contact process of sulphuric acid manufacture, but the assumption finally did not satisfy its proposers. Experimenting in 1912 on the emission of electrons from hot tungsten filaments, Dr. Langmuir observed that traces of residual gas—oxygen at a pressure of 0·1 mm. or a trace of water vapour—practically stopped that emission even at 1,900 deg. C. absolute [all temperatures to be mentioned are on the absolute scale], at which a gas film of appreciable thickness could hardly exist on the tungsten. Yet such films of extraordinary stability were certainly formed. When the residual gas was pure hydrogen, the hydrogen dissociated and seemed gradually to disappear from the bulb being adsorbed by the glass, the gas pressure diminishing. When oxygen was admitted, it did not combine with the hydrogen, but formed WO_2 with the tungsten; there was no dissociation of the hydrogen nor diminution of the gas pressure, until, within about 10 minutes, all the oxygen or nearly all, was bound by the tungsten; then the hydrogen suddenly began to dissociate and to disappear.

The oxygen thus acted as a catalytic poison for the hydrogen, and it had the same effect on ammonia and on methane; the methane would be decomposed into hydrogen and carbon, the latter uniting with the tungsten, but not in the presence of oxygen. All that indicated that the oxygen was bound to the metal surface, not necessarily as an oxide, nor in the atomic condition, but in a saturated layer, not suited to receive a second layer of oxygen, except from a gas which was kept saturated with oxygen; in other words, the film was one molecule in thickness. There were other reasons for regarding the film as mono-molecular. If we assumed the nucleus of the atom as surrounded by electrons, then according to Max Born and Debije, the attraction directed outward would decrease to half the value it had at the surface of the electronic shell at a distance of $0{\cdot}3 \times 10^{-8}$ cm. from the shell, that distance being fairly the same for all atoms.

Atoms should hence interact only when actually in contact. The mono-molecular layer—which might be stable at high temperatures—was in accordance with Perrin's experiments, with Rayleigh's researches on the surface tension of oil films, with the recent experiments of W. B. Hardy—noticed by us in connection with the lubrication problem—and with the calculations of the forces involved by N. K. Adams.

What now were the mechanisms of adsorption and reaction? The recent experiments of Knudsen, Egerton, Langmuir himself and others, though not quite in accord, certainly showed that molecules of mercury, zinc, cadmium, &c., hitting a solid surface, did not immediately rebound, but were condensed to be re-evaporated at rates depending upon conditions. The surface of a crystal was a regular checker-board or lattice; in glass the arrangement was irregular, in charcoal we could hardly assign a definite value to a surface element. In any case the arriving gas molecule would mostly find some free and some covered spots, the latter permanently or temporarily occupied by atoms or molecules fit or unfit to enter into reaction. When molecules condensed on a solid surface, their electrons might be rearranged and their properties be modified. Orientation was an important factor in such a case. Oxygen adsorbed by platinum reacted readily with hydrogen and carbon monoxide, oxygen on tungsten was not ready to react.

The reaction at the surface of a catalyst might in fact occur between adjacent adsorbed molecules or atoms, or between the film and the solid underneath it, or directly as a result of the collision between a gas particle arriving and a film particle. In the case of platinum adjacent adsorbed atoms of oxygen and hydrogen seemed to react, whilst with CO and O the reaction seemed to be between the O particles in the film and the CO striking these O particles. When oxygen struck clean platinum, it was bound in the form of single atoms which would not evaporate at 1,500 deg., but were yet very ready to combine with arriving CO molecules, the resulting CO_2 evaporating immediately. When the phenomena took place in the reversed order, the CO formed an apparently inert film on the platinum, the C being held by the platinum, and the O pointing upward; any arriving O particles then met O in the film and would not combine, though the CO film was held far less firmly than the O film in the first case.

These views, which Dr. Langmuir further developed in a long paper on the "Mechanism of the Catalytic Action of Platinum in the Reactions $CO + O = 2CO_2$ and $2H_2 + O_2 = 2H_2O$," and his remarks on the force-fields, do not, he admitted, solve all the difficulties of the problems, but they are certainly helpful.

The similar views on the parallelism between adsorption and catalysis which the next speaker, Dr. E. K. Rideal, of Cambridge, outlined, were noticed in our comments upon Dr. Rideal's Cantor lectures.* Of the further discussion we will only mention Dr. Langmuir's reply to Dr. Edser as to the spreading of oil on water. If the oil, Dr. Langmuir explained, consisted of asymmetrical chain compounds, with an active group of CO.OH or OH at the end—and only such oils would spread—one or more molecules of the oil drop on water would be so oriented that the active group would dissolve in the water. At that spot the surface tension of the water would at once be lowered and then the greater surface tension of the pure water next the spot would pull the layer out; gravity had very little to do with the phenomenon.

THE RELATION OF RUN-OFF TO RAINFALL.

THE paper on the "Relation of Run-off to Rainfall," read by Dr. Lapworth at the Engineering Conference in July last, dealt with a problem in engineering still unsolved. The conditions, geological, physical, climatic and meteorological, of catchment basins are so varied that a search for a mathematical expression connecting run-off with rainfall appears to be almost in vain.

The run-off of a catchment basin has been defined as that portion of the rainfall which remains on or near the surface of the ground too short a time to be lost or taken up by evaporation. A varying portion of this is underground flow, but that which is subsoil flow in one place may appear as surface flow in another. As the slow movement of ground water tends to equalise the seasonal variations of rainfall the underground flow is fairly constant for any drainage area, and largely governs the low water flow of any stream. The flood flow is caused by surface run-off and is governed by the irregular manner in which the rain falls on the catchment basin. The question that arises from this definition is, how far from the source of the stream, draining the catchment basin under consideration, will the ground flow become surface flow? If a dam were to be constructed across the stream, and an impermeable core were to be carried down to the impermeable stratum underlying the basin, it is possible that the greater portion of the ground flow being held up by the impermeable core would become surface flow. If, on the other hand, no dam with an impermeable core was constructed across the stream, the depth of the plane of saturation, or ground water plane, below the bed of the stream, and the slope of this ground water plane, compared with the slope of the stream bed would require investigation before the question could be answered. At any particular point of the stream there may be a considerable amount of ground flow, but some mechanical contrivance would be necessary to convert it into surface flow at that point. In the case of a reservoir supplying a town in South India with potable water, the reservoir consisted of an earthen dam constructed across a narrow valley filled with talus and *debris* from the hills forming the boundaries of the valley. The dam was constructed without a core wall, and observations over several years after the construction of the reservoir showed, that only 4 in. out of an average rainfall of 45 in. a year was the yield from the catchment basin at the site of the reservoir. The remainder of the rainfall, less losses by evaporation and transpiration by vegetation, passed down the valley as ground flow, and appeared as surface flow in the streams some 4 miles below the site of the dam; the stream having a comparatively rapid fall. In a year of drought the reservoir failed, and although there was a considerable amount of ground flow it was not available as surface flow at a level sufficiently high for it to flow by gravitation to the town. An infiltration gallery was constructed below the reservoir, and the water was raised by pumping to the level of the storage tanks.

In the case of tanks in South India, Colonel Montgomery, R.E., considered 10 in. of rainfall as the least annual average sufficient to cause water to run off the land. He gave as a rough rule the per cent. of rainfall that could be expected as run-off as half the annual rainfall, less 10 in. That is, if the annual rainfall was 40 in., the run-off would be $\frac{1}{2}$ (40 — 10), or 15 per cent. of the rainfall, or 6 in. If the rainfall was 110 in. the per cent. of run off would be $\frac{1}{2}$ (110 — 10), or 50 per cent., equivalent to a run-off of 55 in. Mr. Schuyler considers that when the rainfall in the lower two-thirds of a catchment basin does not exceed 12 in., it is all absorbed in plant growth, and does not feed the streams except when it comes in violent storms.

Mr. Strange gives a table showing the per cent. of run-off to rainfall for various conditions of the catchment basin, which is produced below. ("Indian Storage Reservoirs," W. L. Strange. Spon, London):—

Daily Rainfall in Inches.	Percentage of Run-off where the Ground is		
	Dry.	Damp.	Wet.
0·5	0	10	14
1·0	5	14	20
1·5	7	19	26
2·0	10	25	34
2·5	15	32	43
3·0	20	40	55
4·0	30 to 40	50 to 60	70 to 80

This table has been used by the Madras Irrigation Department to estimate approximately the yield that might be expected from catchment basins of moderate areas, for which only rainfall records were obtainable for a series of years. The following rules were adopted for the classification of the state of the soil:—

1. Rain required to convert a dry catchment into a damp catchment: $\frac{1}{4}$ in. in the previous 1 day; $\frac{1}{2}$ in. in the previous 3 days; 1 in. in the previous 7 days; $1\frac{1}{2}$ in. in the previous 10 days.

For transition from damp to dry half the above quantities are taken.

2. For transition from damp to wet: $\frac{1}{2}$ in. in previous 1 day; $\frac{1}{2}$ in. in previous 2 days; 1 in. in previous 3 days; $1\frac{1}{2}$ in. in previous 5 days.

For transition from wet to damp, half the above quantities are taken.

3. For transition from dry to wet a fall of $2\frac{1}{2}$ in. in one day previous was required. The process was very laborious, but in the absence of more accurate data it gave a reasonable idea of the supply to be expected. Several reservoirs for which the supply has been investigated by the above procedure have now been completed, and time is required to show how far the actual yields approximate to the estimated ones.

It is obvious that in estimating the run-off from rainfall the water year should begin at the commencement of the rainy season. In India the water year would begin on June 1, and end on May 31. For all practical purposes the rainfall from June 1 to December 31 need only be considered; except in the sub-mountain districts in North India, more especially in the Punjaub, where a shallow depression across North India, advancing eastwards gives rain, and more or less heavy and general snow in the Western Hymalayas in January and February.

Although it may be strictly stated that the maximum rate of flood discharge at any locality appears to have no relation to the mean rainfall of the locality. Such floods are of rare occurrence, and may be classed as extraordinary floods; and we would naturally look for periodic floods from those rivers or streams whose catchments generally receive a copious rainfall.

Although in the case of floods the ground is saturated and the losses from percolation and evaporation are small, such are the diversities of the physical features of river basins, and in the distribution of rainfall over them, that no reliable mathematical expression has been devised expressing the flood discharge as a function of the drainage area and intensity of rainfall thereon. Colonel Dickens' formula is applicable to localities with an average rainfall of 36 in. a year, and holds good approximately for localities with a rainfall of from 24 in. to 50 in. a year. The formula is based on the following assumptions: (1) Over 8 acres the rainfall intensity may be as much as 4 in. an hour. (2) Sir P. Cautely allowed $\frac{1}{2}$ in. per hour from small basins which he assumed applied exactly to 50 sq. miles. (3) The Damudah flood discharge was estimated to be at a rate of $\frac{1}{4}$ in. per hour from its catchment of 7,000 sq. miles. (4) The Soan flood discharge from a catchment of 27,000 sq. miles was at the rate of $\frac{1}{10}$ in. per hour from its catchment.

Arranged in tabular form:—

1 Drainage Area. Sq. Miles.	2 Fourth Root of Drainage Area.	3 Run-off, In. per Hour.	4 Product of Col. 2 × 3.
$\frac{1}{12}$	$\frac{1}{3}$	4	1·33
50	$2\frac{1}{2}$	$\frac{1}{2}$	1·25
7,000	9	$\frac{1}{4}$	1·13
27,000	13	$\frac{1}{10}$	1·30

Mean of column (4) = 1·25 or $\frac{5}{4}$ nearly.

If M = drainage area in square miles.

$$M^{\frac{3}{4}} \times \text{inches drained per hour} = \frac{5}{4}$$

$$\therefore \text{Inches drained per hour} = \frac{5}{4} \times \frac{1}{M^{\frac{3}{4}}}$$

If D is the discharge in cubic feet per second,

$$D = 806\ M^{\frac{3}{4}}$$

Dickens' formula as it now stands is

$$D = 825\ M^{\frac{3}{4}}$$

The formula is stated by Colonel Dickens to be considered only a rough approximation.

Colonel Ryves' formula with the same symbols as above is

$$D = C\ M^{\frac{2}{3}}$$

Where C has the following values:—

C = 450 for areas within 15 miles of the coast.
C = 563 for areas 15 to 100 miles from the coast.
C = 675 for limited areas near the hills.

The constants are for the Madras Presidency. Fanning, for American streams, obtains a formula

$$D = 200\ M^{\frac{3}{4}}$$

The actual observed flood discharges from a drainage area of 260 sq. miles was 19,000 cub. ft. per second. This gives the values of C in

Ryves, C = 466
Dickens C = 293
Fannings C = 185
} Formulæ

The statement below shows calculated discharges for smaller catchments, with the same data:—

Catchment Area in Sq. Miles.	2	5	10	25	50	100	200
Ryves 466 $M^{\frac{3}{4}}$	736	1,360	2,162	3,984	6,323	10,037	15,937
Dickens 293 $M^{\frac{3}{4}}$	492	978	1,646	3,275	5,508	9,265	15,581
Fanning 185 $M^{\frac{3}{4}}$	329	706	1,260	2,705	4,819	8,585	15,301

The statement shows that Ryves' formula gives the greatest discharges for catchment areas smaller than that from which the data was obtained. This seems to be correct, as it is possible that the intensity of rainfall on small areas in a large catchment will be considerably in excess of the mean intensity of rainfall over the whole catchment under investigation.

In connection with the "Tank Restoration" scheme Madras Presidency, General Mullins, R.E., directed that in the investigation for the restoration of tanks to assume, in the absence of more reliable data, that the difference between the rainfall and the corresponding drainage for any heavy falls of rain over a standard area of 5 sq. miles would be nil. The considerations which lead to the adoption of this area were that so many of the irrigation tanks have drainages of about that area connected with them, and it was considered that by its adoption the risk of error from under-estimating the rainfall in dealing

* See ENGINEERING, March 25 last, page 363.

with the generality of works would be avoided. And secondly that it was extremely probable that a maximum rainfall might extend over an area of this size. The considerations which lead to neglecting the difference between the rainfall and corresponding drainage over the standard area were: (1) Because in the case of maximum rainfall when this amounts to several inches absorption is relatively small. Five inches of rain distributed equally over 20 days might produce no drainage other than subsoil; whereas if the 5 in. fell in an hour nineteen-twentieths would probably flow off the surface. And (2) because data are wanting and much closer approximation than those possible at present must be made before it would be prudent in the generality of cases to introduce coefficients of reduction. Any formula to be fairly reliable must take into account the maximum rainfall, time of its duration, slope and nature of the country drained. These instructions were issued over forty years ago, and the problem still awaits solution.

NOTES.

Locomotive Building in India.

All who are anxious to see our great dependencies develop into vigorous partners in the company of nations which goes to make up our Empire, will welcome the official announcement that the opportunity in future will be given for builders in India to tender for the construction of locomotives and locomotive boilers for the State Railways. On and after October 1, 1922, tenders will be invited simultaneously at Home and in India, and it is laid down that prices in India must compare not unfavourably with the imported article. It has been for some time a complaint in India that little encouragement has been given to the development of India's own resources, and that home manufacturers have usually benefitted almost exclusively by large engineering contracts, and it will give considerable impetus to the engineering industry in India if it feels that it has a chance of securing important machinery orders. It is to be hoped that the price clause will be fairly worked to, and not employed, for political reasons, to cloak any tendency to inefficiency, and it will be up to our builders at Home so to improve the effectiveness of their means of production that they may still retain a full share of the orders going. Although the price of artisan labour has gone up enormously of recent years in India, that country still has an advantage in this respect, and it will require the very best efforts of our skilled workers if they are to retain high wages, and the Indian market. At present, at any rate, works facilities are greater at Home than in India, and, provided that the works are well run, it has been amply demonstrated, as, for instance, in the American locomotive trade, that high wages, if coupled with good effort, are not an obstruction to successful competition in a market where labour is considerably cheaper.

Institution Papers.

The would-be author of a paper to be submitted to a technical institution is often at a loss to know how best to prepare it. It frequently happens that engineers and others with interesting material at their command, have never given thought to the manner in which contributions appear in a society's journal or proceedings, with the result that when they come to detail, in what they think suitable form, the facts they wish to present, they are guilty of all sorts of crudities, which give the editing staff of the institution a great deal of trouble. It is not to be expected that a member, who has perhaps never attempted anything of the kind in his life before, will compile an explicit description of his work, incapable of improvement by the kindly assistance of skilled editing. This fact is patent since everyone will admit that a first draft always benefits by a deferred révision even by the author himself. Further improvement depends upon the skill of the reviser in picking out those points which according to experience may be expected to excite most interest, and, leaving mere verbal editing alone, in applying his knowledge of what has proved suitable in the way of general arrangement and display of the facts of the case. It stands to reason that work of this kind should only be undertaken sympathetically and in co-operation with the original author, lest the independent efforts of the two should result in a misunderstanding which would lessen the value of the contribution. Such assistance, it may be taken for granted, is available at most of our leading institutions; but it comes often rather late, when the author has already framed and submitted his paper in a form which necessitates considerable work upon it, to bring it into line with the regular publications of the society. It is true that some bodies have, from time immemorial, issued brief suggestions with regard to length, the use of the first person, the summary, and so on, but these do not carry the novice very far. The attempt therefore made by the Institute of Metals to give further help in the earlier stages is to be welcomed. This Institution has issued a small pamphlet of four pages of general notes on the preparation of papers, which we believe to be the first attempt to elaborate the somewhat sketchy hints commonly available. These notes are excellent of their kind and reflect the great care with which Mr. G. Shaw Scott attends to all the minutiæ which go to make contributions to the journal uniform in style and arrangement. If authors generally would follow the lines suggested they would doubtless find that publication would afford them much greater satisfaction, with greater profit to the profession, than often happens. Other societies might well follow suit, with modifications to cover their several methods of illustrating papers, &c. On broad lines there is little to comment upon in these notes, which have evidently been drawn up with great care, and with the assistance of considerable experience. If we may suggest an addition it would be a warning against the use of a figure number in the text, and the repetition of the same on a plate. To avoid confusion, illustrations in the text and on plates should all belong to one sequence. A little more stress, too, might be laid upon inordinate length.

The Problem of Waste.

In his presidential address to the North-Eastern Section of the Junior Institution of Engineers, delivered on Tuesday last, Mr. H. I. Brackenbury dealt with the enormous losses we have suffered in consequence of the waste which has gone on during the last three years. Though impoverished by the war, we have had, he pointed out, a further loss by strikes alone of 150,000,000 working days, which would otherwise have been devoted to the production of goods worth many millions of pounds. Another waste to which he referred has arisen from the failure to make the best use of capital. Excess profits which would otherwise have gone in improving plant and equipping works, became "functionless capital" by being taken to pay for the munitions of war dissipated on the plains of Flanders. As Mr. Brackenbury said, the step taken seemed just, but at the same time it is well to recognise, that our factories are now handicapped in consequence of it. Another point to which he called attention was the waste of energy in the workshops where the muscles of the workman are still employed in doing much useless work owing to faulty arrangements for handling material or finished products. Again, designs of details are often wasteful, parts being unnecessarily heavy or not easy to manufacture. It is, Mr. Brackenbury points out, by saving waste in one way or another that the great captains of industry have made their fortunes, while such fortunes have in all cases represented but a minute fraction of the gain simultaneously and subsequently reaped by the community at large. As a striking instance of this he compared the reciprocating engines formerly used in power-station practice with the turbines which have replaced them. A modern 10,000-kw. steam turbine unit took up, he stated, about the same room as a 1,500-kw. reciprocator set. At the same time, the former would produce 6·6 times the energy whilst consuming only 2·88 times as much coal. In this comparison the steam pressure and superheat had, he said, been assumed to be the same as with the old reciprocator. In the best modern practice, however, the steam turbine took only one-third as much coal per unit generated as did the rival it displaced. The old reciprocator, moreover, weighed about 0·13 tons per kilowatt of rated capacity, whilst the turbine weighed only 0·016 tons per kilowatt of rated output. Mr. Brackenbury also directed attention to the great savings which had been effected by using, for process work and heating, steam which had given up much of its heat for generating power in an extraction turbine.

LITERATURE.

Reflections of a Financier. A Study of Economic and Other Problems. By Otto H. Kahn, with an introduction by the Right Hon. J. H. Thomas, P.C., M.P. London: Hodder and Stoughton, Ltd. 1921. [Price 10*s.* 6*d.* net.]

During the war, the author of these essays proved himself a most active and outspoken partisan in the cause of the Allies, seeking by lectures and pamphlets to place before his adopted country and the world at large, the true origin and bearing of the conflict, in which brutal might and insensate ambition on the one hand strove against the forces of humanity and liberty on the other. He has ever been a warm friend to England, recognising fully the magnitude of the sacrifice and the effectiveness of the effort made by this country and the other members of the Empire, in order that the cause of liberty and justice might triumph. For the kind things he says in the book and elsewhere we thank him; it is not necessary to repeat them, but we believe his words are as sincere as they are welcome. We cordially reciprocate his hearty wish that "the seed sown in the storm of war shall bring forth a tree of unity and concord between the English and American peoples, which shall grow and stand deep rooted for all time." Moreover, Mr. Kahn has proved himself a man of great active benevolence, and to-day our blinded soldiers are benefiting by his thoughtful generosity and well-directed schemes. We believe, too, that he is inspired by a sense of gratitude to America, and is anxious to repay the benefits he has enjoyed by giving her of his best. He is convinced of the worthiness of his mission; he believes that, as a business man, it is his duty to tell the truth as he sees it, to give at all times the reason for the faith that is in him, and, as far as possible, to solve the problems of the hour in the light of the experience he has gained. His outspokenness is the measure of his sincerity. He has given hard knocks in his time, and known the breath of calumny. He has not spared his own countrymen, or rather he has condemned the policy in which they have long acquiesced, and up to a certain point, profited. The relentless persistency and profound cunning that inspired the nation with the demoniacal obsession of power worship and world dominion meet with the sternest censure, and particularly biting strictures are directed against the hyphenated American who, having enjoyed the hospitality and accepted membership in the family of Americans, has regarded the citizenship for which he petitioned merely as a convenient garment that might be worn in fine weather and thrown aside when it became irksome. The author does not need the testimonial of Mr. Thomas, or the recommendation of any similar authority, to make us listen to his words with thoughtful respect. We may, however, subscribe to Mr. Thomas's expressed belief when he says that no one who reads the volume and remembers all that Mr. Kahn did in the great world struggle can withhold his meed of appreciative recognition for the knowledge, character, public spirit, and sympathy of the man whose personality speaks from its pages.

It need occasion no surprise if such a man, in the changed atmosphere that peace, or at least the cessation of active hostilities, has wrought, should adopt the attitude of critic towards those whom he urged to strenuous activity in the day of trial and storm. Blood and treasure were poured out with reckless prodigality, and he welcomed the earnestness of the U.S. Government and the enthusiasm of the people. Now, the object attained, the cause triumphant, the cost has to be reckoned, and more in sorrow than in anger, Mr. Kahn gives expression to the keen disappointment he experiences in the conduct of domestic affairs and the maintenance of foreign relations. With regard to the former

we may listen with sympathetic attention, but it would be impertinent to question the accuracy of the recital or to join in the chorus of disapproval. Perhaps we may remind the author that he is not singular in his sense of soreness, and that our guides and mentors are just as vehement in denouncing the incapacity of the fiscal authorities and the incompetency of a Government that has sanctioned the imposition of undue burdens on trade and commerce. What he urges and justly urges against the incidence of taxation on excess profits and on income has been said with equal bitterness on this side of the Atlantic. Taxation, he reminds us, is essentially a problem of national economics. Its effects are subtle, profound and manifold, and if treated unscientifically may defeat the purposes which the framers of the machinery had in view. Quite so. Our politicians also, apparently, act as though the only problem was to raise the largest possible annual revenue, careless of what troublesome consequences such plans may entail in the future, near or remote. The author seems to be describing the shortcomings of our own legislators when he writes, "joined to unscientific theory, crude economic conceptions, inapt method, lack of moderation and failure to gauge consequences"—Mr. Kahn, it will be admitted, indulges in a rich vocabulary of invective—"the tax legislation has resulted in a revenue measure which has thrown the economic equilibrium out of gear, and produced a harmful and troublesome strain on commerce." And as regards the Excess Profit Duty, have we not read in our own newspapers, many a time and oft, the very words in which it is here denounced: "It lays a heavy and clumsy hand on successful business activity. It is grossly inequitable in its effects. . . . It puts a fine on energy, enterprise and efficiency. It is bound to operate unfairly, freakishly, and unevenly and greatly enhance the cost of things."

And yet Governments do not act wantonly and mischievously. Their interests, as their reputations, require that the taxation proposed should inflict as little hardship as possible. Individually, the framers of taxation schemes are as able as their critics, and yet, both in England and America, when unguided by routine and experience, the results of their methods are marked by faults so patent and by consequences so disastrous, that no adequate defence can be set up. Mr. Kahn does not hesitate to say that tax legislation in America bears unmistakeable evidence of class and sectional bias, and, if such a principle is really at work, he enunciates a proposition which makes one view the possible advent of a purely Labour Government with peculiar uneasiness. He points out that the imposition of a small normal tax, accompanied by enormous surtaxes, acts as a strong stimulant to waste, inasmuch as the executive do not feel that salutary restraint which comes from the fear of being held to account by the people for the resulting tax burden. By the opiate of such taxation, which apparently touches the labour classes very little or not at all, the masses of the people can be lulled into a sense of relative indifference to Government wastefulness, but the inexorable fact remains, that Governmental extravagance is visited not upon one class, but upon all the people.

At present it would seem from the author's figures, which we neither endorse nor confute, that the burden of income-tax is more uniformly distributed in England than in the United States. Leaving on one side the question of exchange, a most disturbing factor in actual comparisons, our English normal tax is 30 per cent., with certain abatements in accordance with the smallness of the income taxed. In America the normal rate is only 8 per cent., with abatements to 4 per cent. on the first $4,000 of taxable income. But by reason of surtaxes, the maximum rate of taxation is 73 per cent., and applies to all sources of income or profit, except tax-exempt securities. That, says the author, and we hope it is true, is the highest rate of income-tax existing in the civilised world. Truly, those who won the war have to pay for it. But the rich American can escape his contribution if he elects to invest in tax-exempt bonds, a class of securities that gives a nominal interest of about 6 per cent., but, by reason of the rise of tax with increase of income, to the wealthy these bonds yield as much as 20 per cent. Such investment the author regards as a grievance. He contends that by the withdrawal of so much capital, the investment market grows stagnant, and the aspiration of New York to become the first financial market of the world is strangled at its birth. From want of capital, enterprise is hampered, production retarded, and unemployment increased, and the accumulating capital so necessary for the expansion of the country's business is not forthcoming. Mr. Kahn states these conclusions with the certainty of axioms, and they may be to a great financier, who can see the resources of an Empire in their true perspective, but they leave us unconvinced. The money invested in tax-exempt securities is not locked up or destroyed: it circulates and should be equally fructiferous, though it follows channels that do not appeal to the financial expert. No doubt, it is due to ignorance, but "the coffers of the Government," which appear to be bottomless but all absorbing, is, to us, an unmeaning phrase.

Much of the book is concerned with taxation and finance and the employment of the latter in various ways, as the management of railways, the Stock Exchange and other matters of "high finance," from which we may profit, as on such matters the author is well informed. We are further permitted to see his interpretation of American opinion towards such topics as the Versailles Treaty and the League of Nations. Mr. Kahn does not halt between two opinions; his view is not troubled by any shades of difference. We could have welcomed, however, a nice balancing of motives between conflicting interests, a keen appreciation of the difficulties that had to be overcome, some credit given for honesty of purpose or judicious handling of incompatible claims, but, what is of greater moment, there is no reasoned judgment for the wholesale condemnation so emphatically uttered. "I have been at pains to read through the Peace Treaty, including the Covenant, from beginning to end. I laid it away sore at heart and sickened. The Treaty falls grievously, most grievously, short of realising the high hopes of the world for a peace worthy of the spirit and aspirations which animated the Allies and America during the war, and at the conclusion of the Armistice."

The same uncompromising attitude is presented to the policy embodied in the League of Nations, to which, in the form originally presented to the Senate, the strongest opposition is offered, because it is urged that the part America played in the war does not make it incumbent upon her to entangle herself in the age-long racial squabbles and intrigues of Europe and Asia, or to become the guardian and guarantor of an arbitrarily and artificially-remodelled world, put together in disregard, more or less, of the evolution of centuries and of the proven qualities and characteristics of races. But if not "incumbent" it might be expedient for the United States to accept a certain amount of responsibility, in order to prevent the recurrence of regrettable consequences, which would entail all the evils her rulers foresaw when they advised America to enter into the European struggle. It may not be incumbent on the allied nations to give Germany the means of resuscitating herself, and re-entering the comity of nations, but it may be wise to do so, lest worse befall. Policy is guided by self-interest, no less than a sense of duty.

Mr. Kahn discusses many other topics, always informingly, if somewhat superficially, but these must be passed over, though they will well repay reading. He gives a biographical sketch of the great railway magnate, Mr. E. H. Harriman, and succeeds in reproducing the characteristics of a virile personality. He enters the domain of art, and lectures the Americans on their imperfect judgment, often mistaking the bad and meretricious for the good and worthy. An American audience, it is said, is apt to confound sentimentalism for feeling, to mistake ranting for passion, exaggeration for truth, coarse jokes for wit, and tawdry tinsel for beauty. This is a harsh judgment, but the author is as confident in the infallibility of his opinions as he is in matters of finance. Finally, he reproduces a letter, written to *The Times*, last April, in which he claims to interpret the views of the "man in the street" on the relations of Americans to European politics. Intentionally or otherwise, it is to be inferred from this impersonal summary that the thoughtful onlooker regrets the self-denying ordinance to which he subscribed in the moment of his enthusiasm. He finds the world no better for his sacrifice; it is torn by the same animosities and jealousies; strife and pettiness have still to be encountered, and he decides that the game was not worth the candle. Moreover, when he sees the material spoils of war shared by other nations, he feels acutely the burden of his country's debts, and the growing accumulations due to pensions and bonuses. Of the extent of his disillusionment there is no doubt, but it would be too much to say that he regrets his decision.

BOOKS RECEIVED.

Technical Report of the Advisory Committee for Aeronautics for 1917–18. Vol. III. *Seaplanes, Fabrics and Instruments (Strength of Construction, etc.) with Appendices.* London, Manchester, Edinburgh and Cardiff: His Majesty's Stationery Office. [Price 21*s.* net.]

Aeronautical Research Committee. Reports and Memoranda, No. 729. *Note on the Comparison of Metals as Aeroplane Structural Materials.* By A. J. Sutton Pippard, M.B.E., D.Sc., Assoc.M.Inst.C.E. London, Manchester, Edinburgh and Cardiff: His Majesty's Stationery Office. [Price 2*d.* net.]

Industrial and Power Alcohol. The Sources, Production and Denaturing of Alcohol, Its Manifold Chemical and Physical Applications in Industries and Manufactures, and Its Use for Internal Combustion Engines. By R. C. Farmer, O.B.E., D.Sc., Ph.D., F.I.C. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* 6*d.* net.]

The "Electrician" Annual Tables of Electricity Undertakings, 1921. London: Benn Brothers, Limited. [Price 10*s.* net.]

Oil Flow in Pipe Lines. Comprising Charts showing the Pressure Loss in different-sized Pipe Lines, the Conversion of Viscometer Readings, the Horse-Power required for Pumping. By R. S. Danforth, Assoc.M.Am.Soc. C.E. San Francisco: King Knight Company [Price 3 dols.]

Aussergewöhnliche Druck-und Temperatursteigerungren bei Dieselmotoren. Von Dr. Ing. R. Colell. Berlin: Julius Springer. [Price 20 *marks.*]

The Scottish Trade Courier: A Record of Manufacturers and Traders who desire to Develop Foreign and Colonial Business. Fifth Year of Issue. Glasgow: Glasgow and West of Scotland Guardian Society, Limited.

Department of Overseas Trade. Report on the Economic and Financial Conditions in South Africa, June, 1921. By W. G. Wickham. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1*s.* 3*d.* net.]

Handbook of Construction Equipment, Its Cost and Use. By Richard T. Dana. First Edition. New York and London: McGraw-Hill Book Company, Inc. [Price 36*s.* net.]

Concrete Designers' Manual: Tables and Diagrams for the Design of Reinforced Concrete Structures. By George A. Hool, S.B., and Charles S. Whitney, M.C.E. First Edition. New York and London: McGraw-Hill Book Company, Inc. [Price 24*s.* net.]

Heat Treatment of Soft and Medium Steels. Theory and Practice of the Preliminary Heat Treatment designed to give Maximum Toughness to Steels used for Machine Parts. By Federico Giolitti, Ph.D. Translated by E. E. Thum and D. G. Vernaci. First Edition. New York and London: McGraw-Hill Book Company Inc. [Price 30*s.* net.]

Drawing Room Practice. By Frank A. Stanley. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 15*s.* net.]

Road Transport.—Occasion will be taken of the forthcoming Commercial Vehicle Exhibition by the Institute of Transport, to hold a congress at Olympia on October 17. The proceedings will be opened at 11 a.m., Mr. A. Dryland being in the chair. At the morning meeting a paper on "Highway Maintenance and Administration under Modern Traffic Conditions" will be read and discussed, while in the afternoon, when the meeting reopens at 2.30 p.m. after the mid-day adjournment, a paper on "The Evolution of the Motor Vehicle for Goods and Passenger Service" will be taken. This paper will be submitted by Mr. P. F. Smith, and the chairman will be Sir Philip Nash, K.C.M.G., C.B.

Institute of Transport Awards.—The following awards have been made by the Institute of Transport for papers presented to that body during the sessions 1919–20 and 1920–21: Railway gold medals to Mr. Arthur Watson for his paper on "Some Advantages of Control as Applied to Traffic on Railways," and to Mr. W. G. Bishop for a paper on "Locomotive Shed Practice on the South African Railways"; Road Transport gold medal to Colonel C. H. Brassey for his "History of Roads"; Aerial Transport gold medal to Major-General Sir F. H. Sykes, G.B.E., K.C.B., C.M.G., for a paper on "Aviation and Air Transport"; Graduate medal to Mr. W. F. Steel for a paper on the "Potato Traffic from St. Malo to Southampton Docks"; Student medal to Mr. C. V. Miller for a paper on "Freight Train Loading"; Modern Transport premium to Mr. J. W. Parker for a paper on "The Use of Trays as a Means of Reducing Goods Handling."

THE LATE SIR W. E. GARFORTH.

We regret to announce the death, at the age of 75, of Sir William Edward Garforth, so well known for his pioneer work in connection with safety in coal mines. Although previous investigation work had been carried out on the Continent it was left to this country, and to the enterprise of Sir William, to bring practical results out of what had previously been laboratory experiments, both as regards certain classes of explosions in coal mines, and also with regard to life-saving work.

Sir William was connected with colliery working from 1865, when he went to the Leconfield Colliery forming part of the New Moss coalfield. He subsequently became manager and managing director of Messrs. Pope and Pearsons' Collieries, later occupying the position of Chairman of the company. As a result of study and experiment which dated back to 1886, Mr. W. E. Garforth became convinced that stone dust was an effective prevention of the spreading of coal dust explosions. This was conclusively proved in a research carried out by a Committee of the Mining Association of Great Britain. This committee raised the sum of 10,000*l.* to defray the cost of full-size experiments in a gallery constructed to Mr. W. E. Garforth's design, erected at the Altofts Colliery, Mr. Garforth being on the committee, and the main director of the experiments. The type of gallery used was afterwards adopted with modifications at Pittsburgh, in the United States. The results of this work have been of inestimable value, and Mr. Garforth's leading association with it would alone entitle him to a distinguished place among those whose efforts have been directed to extending the safety of coal mines.

As a result of the Courrieres colliery disaster, Mr. Garforth turned increased attention to rescue work, and devised the portable breathing apparatus known as the Weg. (the initials of the inventor), which in time became known throughout the mining world. Although not actually the first, the Weg. apparatus may be said to have been one of the very first of these appliances of real value and dependability, and it was favourably reported upon in a report of the Royal Commission on Mines, published in 1907. This apparatus was largely the result of experiments carried out by Mr. Garforth at an experimental station at Altofts Colliery, erected in 1901. This rescue station, which was not only intended to provide the apparatus suitable, and men required, for rescue work, but was devised with a view to the practical training of the men in their work and the apparatus employed, had the distinction of being the first of such stations not only in the British Isles, but elsewhere. In 1908 the idea was so far adopted that other rescue training stations had been inaugurated in this country and abroad, and the idea became an established feature of mining organisation. To Mr. Garforth belonged most of the credit for pioneer work on practical lines in this direction, and the knighthood conferred upon him in 1914, was generally considered to have been well earned. Sir William's other work led him to invent a deep coal undercutting machine, and a method of testing gas in mines by means of the safety lamp.

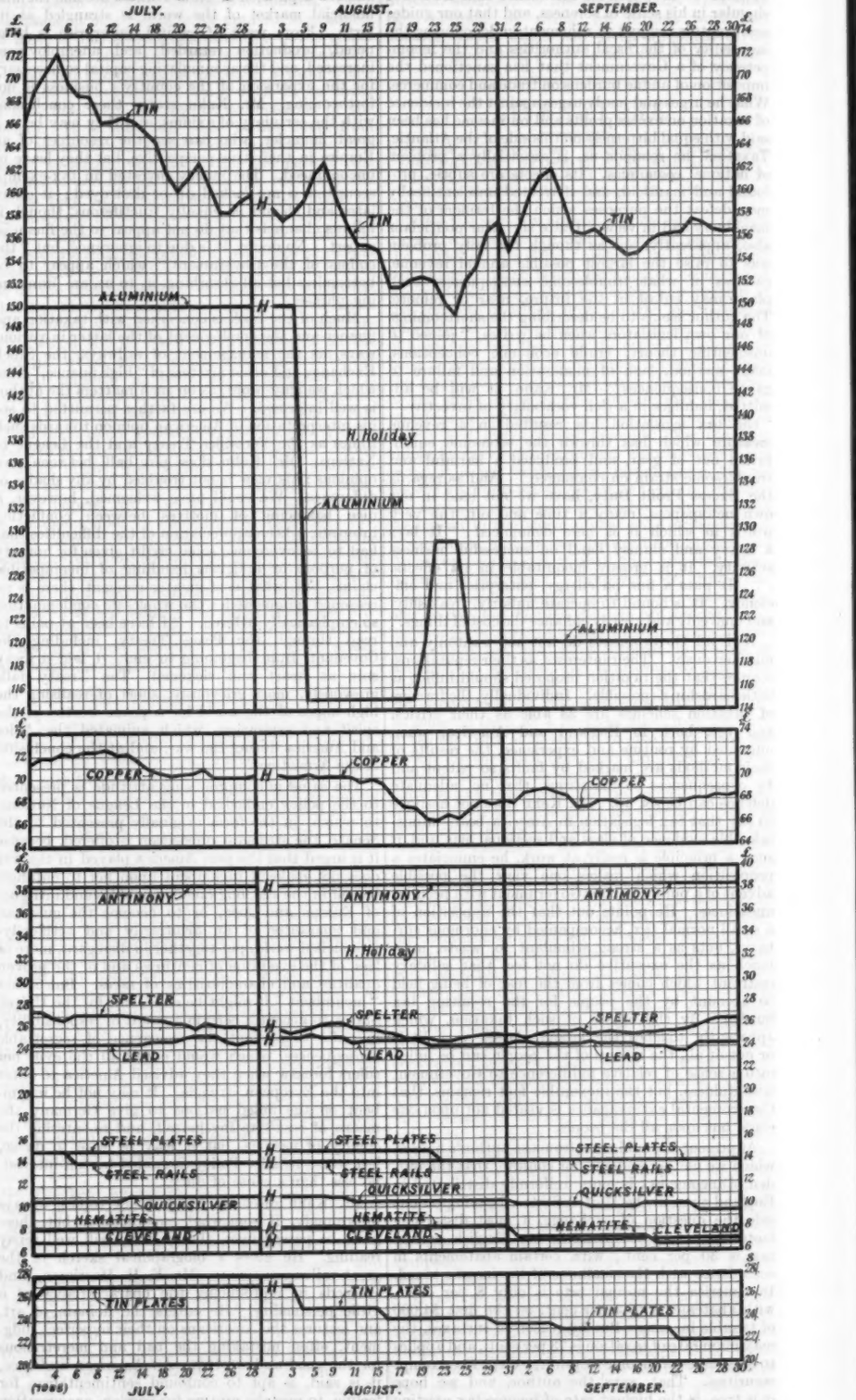
Sir William was chairman of the Mining Advisory Committee of Leeds University. He was president of the Midland Institute of Mining, Civil and Mechanical Engineers from 1911 to 1914, was chairman of the Standing Committee on Mining set up by the Advisory Council for Scientific and Industrial Research, and received the honorary degree of LL.D. from both Leeds and Birmingham Universities. The Fothergill gold medal was awarded to him by the Royal Society of Arts in connection with trials of the Weg. rescue apparatus, and he received several other medals from mining and engineering bodies. He was made Justice of the Peace for Cheshire in 1876.

The Society of Consulting Marine Engineers and Ship Surveyors.—The secretary of the above Institution informs us that its registered offices have been changed to No. 32 Fenchurch-street, London, E.C. 3.

Standard Creosote Specification.—A standard specification has recently been issued by the British Engineering Standards Association for creosote for the preservation of timber. This covers the requirements of creosote suitable for the treatment of railway sleepers and for telegraph poles, &c. It includes a description of the substance and gives limits for specific gravity, fluidity, water content, distillation, tar acids and matter insoluble in benzol (benzene), these being followed by appendices giving the necessary tests. The committee which has dealt with the subject, under the chairmanship of Mr. W. W. Grierson (engineer-in-chief of the Great Western Railway), has had the co-operation of various Government Departments and industrial and scientific organisations, as well as a number of railway companies. The specification can be obtained from the Secretary of the British Engineering Standards Association, 28, Victoria-street, London, S.W. 1, price 1*s.* 2*d.* post free.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

THE HARDENING OF TUNGSTEN STEELS.

The Journal of the Iron and Steel Institute, vol. ciii, recently issued, contains the official report of the annual meeting held in May. The papers taken at this meeting and the discussions were dealt with in our columns at the time, but the new volume contains correspondence of interest on, among others, Mr. S. N. Brayshaw's paper on "The Prevention of Hardening Cracks in Tungsten Tool Steel." In the main this paper may be summarised in the statement that a quantity of evidence was brought forward to show that bars of tungsten tool steel can be annealed, or heat treated in such a way that tools of difficult shapes made from them will not crack on hardening, even when the tools are thoroughly hardened by a severe treatment; and further, that such steel can be so treated that taps or screw gauges made from it do not change in pitch on hardening.

Among the members sending in written communications was Dr. A. McWilliam, who wrote that he had done a considerable amount of work on hardening and tempering, apart from the various series published by McWilliam and Barnes, which were all done, in the possible ranges, in two of Mr. Brayshaw's salt-bath furnaces, and he had gradually been impressed with what he came to regard as a fact, that the condition of the steel with regard to former heat treatment was of great importance, although it might have been thought that heating before hardening would have neutralised most ordinary heat treatment effects. He thought Mr. Brayshaw had shown clearly that the heat treatment before hardening was of the greatest importance and had found what that previous heat treatment should be.

Professor H. C. H. Carpenter wrote that it was important to realise that the austentite to pearlite inversion really involved two changes, namely, the conversion of γ to α iron and the precipitation of cementite from solution. This at once indicated the possibility of an inversion by steps such as was suggested by Mr. Brayshaw. It appeared to him (Professor Carpenter) that other evidence existed indicating the possible step-like nature of the Ac 1 and Ar 1 transformation. He considered that further research on that matter was called for and, if undertaken, would throw considerable light on the important results already obtained. The results might quite conceivably affect the form of the equilibrium diagram.

Mr. P. B. Henshaw, in a contribution, discussed the method of hardening. He confirmed some of Mr. Brayshaw's figures and drew attention to a further change point at 682 deg. C. which he had found in this steel.

Mr. J. Neill Greenwood wrote that it was remarkable that not until the normalising temperature had been passed was there any increase in length on quenching from 732 deg. C. and 725 deg. C., although many of the bars were glass hard, so that the $\gamma \rightarrow \alpha$ change, along with its expansion, had taken place, and the net expansion due to carbon in solution should have persisted. It was impossible to say whether that was due to the special elements present, or was purely a function of the heat treatment.

Professor C. Benedicks considered that if the steel before the standard hardening were especially soft, that probably depended on the fact that a considerable quantity of cementite, as globules, was precipitated in the metal—probably in a very regular way. It appeared quite plausible (especially if the retarding influence of tungsten, even in so small a quantity as 0·8 per cent. were taken into account), that 15 minutes at 760 deg. were insufficient to dissolve the cementite entirely (or to a degree corresponding to saturation). At the end of the 15 minutes, the proportion of dissolved carbon would be higher, if already in the blank the proportion of dissolved carbon was comparatively high. If, on the other hand, the proportion of dissolved carbon in the blank—owing to prolonged soaking at a temperature below Ac 1. 2. 3—were low, a comparatively low proportion of hardening might be expected after the 15 minutes of the standard hardening. It resulted from those considerations that the cutters which had a slight liability to crack were those in which the content of hardening carbon at the final quenching was comparatively low.

Dr. McCance questioned the condition of the steel as received by the author, and criticised the standard hardening adopted in the research; also he suggested that the hole in the test bars may have caused variations in the length measurements.

Mr. Brayshaw, replying to the verbal discussion as well as the written communications, wrote that the difficulties of tool steel hardening were so great, and so little understood, that even scientists seemed to give way to a kind of fatalism on the subject. He was not prepared to acquiesce in an admission of impotence in the face of strangely discordant results which were within common experience. Reviewing the discussion as a whole, he felt that in dealing with tool steel there was too often a sort of tacit acknowledgment, not only that there was something unknown, but something unknowable. To not a few it was almost impious to suggest that industry urgently demanded more knowledge about such matters as the transformation changes, or the distribution of carbon, and the time it took to go into solution. The paper was written to draw attention to a certain desirable condition into which tool steel might be brought prior to hardening. The condition in question might well have escaped notice in the past, for apparently it could not be detected by analysis or by ordinary hardness tests, neither was it shown by the microscope at 500 diameters, and no indication of it appeared to be forthcoming from bending tests, yet it produced a change in behaviour which made all the difference between success and failure in hardening. It was of practical interest that a particular treatment previous to hardening brought the steel into a condition that had not hitherto been recognised, but which was of the very first importance to the hardener. By an intelligent application of the information given not only would hardening losses cease, but there would be a great increase in efficiency. The theoretical explanation might be very simple, like the one offered by Professor Benedicks, but the fact would lose none of its importance thereby.

WAGES: BRITISH AND FOREIGN.

Whilst wage re-adjustments are provoking so much controversy a few facts, figures, and points of an international character may be offered. Beginning with Germany, the *Frankfurter Zeitung* gives German wages in paper marks, for the month of May, 1921:—Wages, per hour, averaged, for railwaymen, 5.90 marks; for bricklayers, 5.90 marks; for weavers, 5.14 marks; for carpenters and joiners, 7 marks; for metal working mechanics, 6.60 marks; for chemical workers, 6.40 marks; for tailors, 6.25 marks; and for bootmakers, 5.20 marks. Miners' wages are given by this journal as averaging 54.10 marks per shift, or day, of seven hours; but another source gives the wages average in the famous Ruhr district as about 75 marks per day. To see these figures in a true light, so far as they affect international competition, it is necessary to remember that the German mark is only about equal to three farthings in English currency.

Recently there has been some discussion about British ships going to the Continent for repairs whilst our own shipyard men have been idle, or on short time. On this point some figures are supplied by Messrs. Smith's Dock Company, of Shields. They deal with conditions at the close of last year. These show that wages in Rotterdam yards are paid under three categories—skilled men, skilled labourers, and unskilled labourers. Thus, all carpenters, joiners, engineers and boilermakers (platers, riveters, framesmiths, &c.), are paid alike. The wage per hour is: Skilled men, 1*s.* 7½*d.*; skilled labourers, 1*s.* 6½*d.*; labourers, 1*s.* 3½*d.* At home the wages vary for each trade, but the following may fairly be compared with the above: Skilled men, platers (lieu rates), 4*s.* 7*d.*; joiners, 2*s.* 3½*d.*; blacksmiths, 1*s.* 11½*d.*; strikers, 1*s.* 7*d.*; platers' helpers, 1*s.* 8½*d.*; and shop labourers, 1*s.* 7*d.* Conditions of work: In Rotterdam the men work 48 hours a week, as against our 47. As here, overtime worked two hours after the usual hours is 25 per cent. extra; otherwise, 50 per cent. extra; Sundays and holidays, 100 per cent. extra. In Rotterdam there is no union limit to overtime a man may work. Here overtime is limited to six hours per week. But in Rotterdam the necessity for overtime does not arise as it does here, because the men there work two shifts and often three shifts. Rotterdam repairers offer shipowners a guarantee that the men will work 20 hours a day on repairs. Here we work one shift only. The importance of working two or three shifts per day on repair jobs to vessels will be obvious. Time is money where tides, sailings, contracts, and often perishable cargoes are concerned. Another item of Continental news is that Italian iron and steel workers have just accepted a 20 per cent. reduction, and have further agreed to a series of reductions which will carry wages down to exactly half their present level by the middle of 1922. This will simplify the making of forward contracts.

Turning to America, it is found, among other things, that the wages paid by the United States Steel Corporation—the trust which owns half the iron and steel works in North America—averaged 6·96 dollars per man per day during 1920. But this year there have been three wage reductions. What the average will be now cannot be said, but what is called the "common" rate—that is the general unskilled rate—has been fixed at 30 cents per hour. Normally, that would be 1*s.* 3*d.* in the English equivalent, but the American dollar is at a premium, compared with the pound sterling. Roughly, we may put it, for international competitive, or exchange purposes, that the American unskilled steel works labourer is being paid about 1*s.* 9*d.* per hour in English money, or value. Here it may be mentioned that the quarter of a million men employed by the United States Steel Corporation produce in a normal year 12,000,000 tons of steel, whilst half a million men employed by our British steel works produce only 8,000,000 tons. But due allowance must be made for different processes, different mechanical power, and for different quality of product—the latter point being in favour of Britain and the two former in favour of America. In other words, whereas the labour cost per ton of finished steel product for sale was 14 dols. in 1901, when the Corporation was organised, it was 40 dols. per ton in 1920. This year's wage reduction will probably have reduced the average to about 30 dols.

Turning to the great foundation industry of coal mining we get some remarkable comparisons. German miners' wages, ranging from 50 marks to 75 marks per day, will work out at something less than 100 marks per ton of coal. With the mark worth about ¾*d.*, this means a labour cost, so far as competition is concerned, of little more than 5*s.* per ton, at the pits, against a British cost of nearly 25*s.* per ton. It is no wonder that German steel can be sold so much under our British cost of production, though if the exchange is rectified there may be a different story to tell. United States miners were earning, in the month of January, this year, an average of 7*l.* 5*s.* per week, in English money, according to the reports of the Federal Commissioner of Labour Statistics. As the normal American output is 20 tons per week, per man, it follows that the average labour cost of producing coal in the United States was about 7*s.* 3*d.* per ton last winter. At the same time our British miners were getting rather less than 6*l.* a week for slightly less than 4 tons per week—30*s.* per ton, against the American 7*s.* 3*d.* Recent wage reductions will have brought our pit labour cost to a trifle under 25*s.* per ton, and the American cost will be something under 7*s.*, as there has been a wage reduction in the United States since January. We have thus arrived at a stage where the fuel cost alone of a ton of British iron or steel is as much as the combined ore, lime, fuel and labour cost of a ton of American or German iron or steel.

THE YELLOW RIVER BRIDGE CONTRACT.

To the Editor of Engineering.

Sir,—The subjoined statement giving particulars of the tenders received for the Yellow River Bridge might be interesting to you.

The opinion was expressed to the undersigned by the chief Chinese director, that British firms do not seem to care for Chinese business, and I am inclined to agree with him. Whilst Messrs. Carlowitz could apparently afford to work up, and out, six sets of specifications, the only British house tendering could not, or would not, afford even to work out the total cost on one tender.

Our people seem to think that orders will come to them without their hunting them. It may be we don't need the orders at home, in which case there is nothing to be said; but if we do want orders we need to gird our loins and work as our competitors are doing with all their might.

Yours faithfully,

Moorebennett.

Engineers of China, Limited, Peking, August 12, 1921.

COPY.

The tenders for the Yellow River Bridge date closed June 30, decided, after months' consideration by the Advisory Board, first prize for plans of 80,000 dols., given to Société Belge pour l'Exportation d'extreme Orient, and second prize of 25,000 dols. to Brossin et Cie, both French houses.

The successful tenderer was the first above-named, the price being 10,500,000 dols.

The unsuccessful tenderers were:—

	Dols.	
John R. Freeman, tender rejected, not representing maker	—	American.
Koran Sugahara, Tokio ...	14,972,229·00	Japanese.
W. Deydier, St. Gervais, Siene	8,462,000·00	French.
Union Enterprises Industriel, Paris	9,331,268·00	French.
Societa Nazionale Delle Offine, Turin	8,310,356·00	Italian.
Sidney Powell, Engineer, Shanghai (rejected) ...	8·709,454,00	American.
Société Etude et de Construction, Société Belge de Chemin de fer de Chine, Bruxelles ...	14,902,844·42	Belgian.
East Asia Company, Dairen	9,736,333·00	Japanese.
Cleveland Bridge and Engineering Company, Limited	5,165,232·70	English.
Arthur McMullen and Company, Minneapolis ...	12,477,157·11	American.
Ditto	13,369,720·00	American.
Ditto	12,818,074·55	American.
Hein Lehmann et C., Dusseldorf	2,601,427·19	German.
Etab. Daydo et MM. Schneider et Cie ...	10,063,665·18	French.
Ditto	10,463,644·88	French.
Ditto	10,690,344·25	French.
Ditto	11,142,187·62	French.
Ditto	10,807,182·62	French.
Yu Foeung Industrial Development Company, Peking	8,927,083·00	Chinese.
Ditto	8,198,693·25	Chinese.
Ditto	8,691,984·44	Chinese.
Ditto	10,149,245·99	Chinese.
Ditto	9,742,555·99	Chinese.
Ditto	10,428,864·00	Chinese.
Lam Ginnes and Company, Inc., New York ...	9,804,187·00	American.
Etab. Brossard et Mopin...	10,846,682·00	French.
Ditto	10,344,755·98	French.
Ditto	10,380,472·00	French.
Ditto	10,111,102·00	French.
Ditto	9,700,499·00	French.
Ditto	9,504,502·31	French.
Chung Hsi Eng. Company, Shanghai	23,018,327·00	Chinese.
Carlowitz and Company, for Fred. Krupp and Company	9,481,944·00	German.
Ditto	8,490,914·00	German.
Ditto	8,053,400·00	German.
Ditto	7,451,180·00	German.
Ditto	10,768,895·00	German.
Ditto	9,440,525·00	German.
Kai Cheng Engineering Company, Peking ...	14,000,000·00	Chinese.
Comp. General l'Extreme Orient	9 2 90,184·31	French.
Ditto	10,490, 981·00	French.

Conditions: Bidder had to prove he represented directly the house he bid for, and that house had to prove it had built great bridge successfully. Bidder could give variants. Carlowitz gave six variants and certain others five and six each. British offers: Only one received, and that only for the bare steel.

VENTILATING, HEATING, AND HUMIDIFYING PLANT.

It is only in comparatively recent times that a close study has been made of the conditions which have to be met in the proper heating and ventilating of factories and public buildings, and the number of defective installations which are in existence is painfully large. The unsatisfactory nature of very many heating plants arises essentially from the fact that they are heating plants merely, and that in their design no consideration has been given to the fact that the actual temperature inside a building is no proper measure of the conditions from the point of view of the comfort and convenience of the users. The whole question of the relation between the temperature and the humidity has been overlooked. Very many ventilating plants again are defective since they are designed merely to discharge cold air into the buildings, and frequently result in a very uneven temperature distribution or serious draughts.

For satisfactory results in large buildings there is little doubt but that heating and ventilation must be worked together, and for the best results some method of controlling the humidity of the supplied air must also be incorporated in the plant. As an excellent, and in some ways unique, example of the latter class, we may instance the plant which has been installed in the New Court House for the London Quarter Sessions, which has been designed and equipped by Mr. W. E. Riley, F.R.I.B.A., M.Inst.C.E., for the London County Council at Newington Causeway, S.E., and was completed a few months ago. The ventilating and heating installation for the building was also designed under the supervision of Mr. Riley, who was assisted by Mr. T. Moodie of the Heating Section of the Architects Department. The heating-system, so far as it was necessary for the temporary occupation of the building by the Government, was installed about four years ago and the ventilating and air conditioning plant was subsequently installed by Messrs. The Buffalo Forge Company, Limited, of 24, Buckingham Gate, S.W. 1, whose standard design of air washing and humidifying plant was adopted.

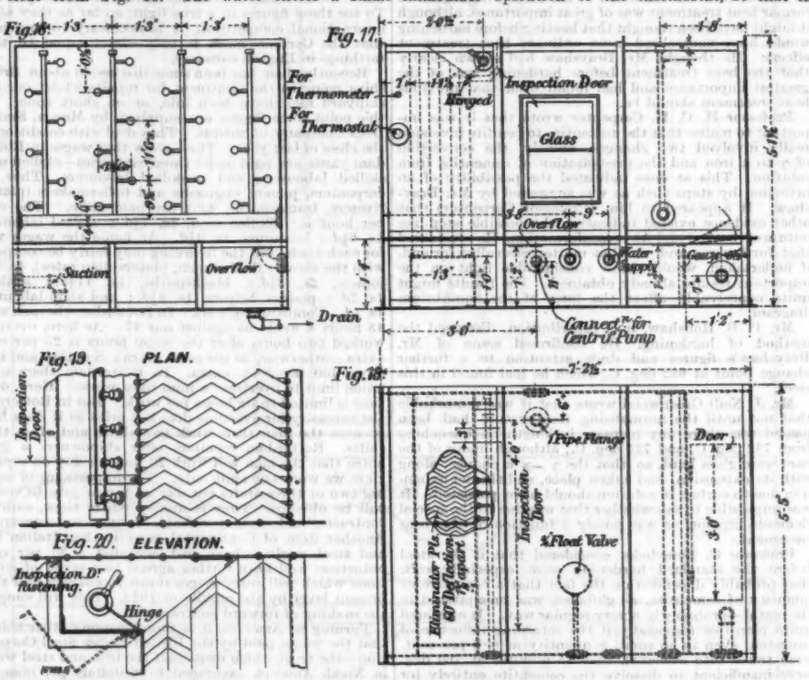
This new Sessions House is of very considerable architectural merit, and is worthy of the excellent record which the London County Council holds for the public buildings which it has erected. This aspect of the Sessions House lies somewhat outside our sphere, but we may refer to the two interior views of one of the courts in the building, which are given in Figs. 1 and 2, on Plate XXVII, and which well show the merits of its design. From our present point of view the interesting feature of this building is that the general lines and details of the heating and ventilation have been so fully worked out that although it is situated in an unfavourable part of London, and although its courts have to accommodate some very miscellaneous crowds, a remarkably satisfactory state of its internal atmosphere has been obtained even under the most unpropitious conditions.

The arrangement of the ventilating ducts in the building will be followed from Figs. 3 to 9, on Plate XXVII. These views, in conjunction with Figs. 1 and 2, already referred to, give a good general idea of the main apartments. Figs. 1 and 2 show Court No. 1. The underlying feature of the ventilating and heating system is the supply of conditioned air to each apartment on a Plenum system, combined with a hot water radiator heating system. The supplied air is washed and its dew-point automatically controlled so that practically any percentage of relative humidity, or any degree of heat, can be automatically maintained in the rooms. Conditioned air is supplied by fans, and in most cases the air inlets to rooms are situated behind the radiators and are provided with louvre regulators. In addition to the air supply fans, extractor fans are fitted for the three courts.

The air-conditioning apparatus, supplied by the Buffalo Forge Company, which is of the well-known Carrier type, is in duplicate, and is situated in two chambers in the basement. Views of one of the installations are given in Figs. 11 to 15, on Plate XXVIII. The plants are identical except that one is built left-hand and one right-hand to suit the building and the lay-out of the ducts. Each is capable of delivering 8,400 cub. ft. of conditioned air per minute, which gives a total approximately equal to eight changes of air per hour in the courts and four to five changes in the smaller rooms. Each plant consists of a spray chamber with baffles, in which the air is drawn through a finely divided water spray. Heater coils are provided for the treatment of the air after passing through the conditioning plant, while means are provided for heating the spray water to the necessary dewpoint temperature in the winter. All heating coils may, of course, be cut out of operation in the summer, when the air is cooled by the water spray. The air supply to the conditioning plant is drawn from the top of the building.

Having briefly sketched the main features of the plant, we may now refer to some of its parts in more detail. The general arrangement is well shown in Figs. 13 to 15, while the spray chamber is shown separately in Figs. 16 to 20, on this page. It is constructed of steel plate, galvanised, and is connected at one end to the inlet duct, as shown at the right-hand of Figs. 13 and 14. The fan drawing air through the chamber and discharging to the supply ducts is connected at the other end. The fan shown separately to the left on Figs. 13 and 14 is one of the extraction fans for drawing foul air from the courts and has no direct connection with the conditioning plant. At the left-hand end of the spray chamber there is a series of vertical vee-shaped baffles which can be seen in section in Fig. 18 and to a larger scale in Fig. 19. In front of these stand four vertical pipes with short horizontal branches as shown in Fig. 16. These branches carry spraying nozzles of the type shown in Fig. 10 on Plate XXVII, and the result of the arrangement is that the air passes through a length of some 4 ft. of very finely divided spray and then flows over the baffles.

The nozzles are of very simple construction, as will be clear from Fig. 10. The water enters a small



circular chamber tangentially, which gives it a whirling motion, and as the approach to the discharge orifice is conical the whirling speed of the water greatly increases as it nears the discharge. It issues in a minutely divided and very effective spray. The baffles, or eliminators, are made of copper and collect any spray which may be carried forward by the air, the two outside vees being formed with lips more effectively to ensure this separation. The eliminators also remove any dust, or dirt, which may be carried forward by the air so that clear and conditioned air only passes forward into the building. Any dirt and dust contained in the incoming air is washed down into the base of the spray chamber, where it settles. A flushing arrangement is provided for clearing out. The water in the base of the chamber is maintained at a fixed depth by a ball valve, and a motor-driven centrifugal pump draws it off through a strainer and continually circulates it through the sprays.

As mentioned earlier, the temperature and humidity of the air are controlled automatically. This is brought about by the heating of the spray water, and by the re-heating coils in the air discharge, which are shown in Fig. 14. The temperature of the spray water is controlled by an enclosed heater which takes the form of a cylinder with internal tubes, and which can be clearly seen in Fig. 12. It may also be seen in Figs. 13 to 15. This heater obtains the requisite heat from the hot-water heating system, which is independent from the conditioning plant, and to which we will refer again later. The actual automatic operation is applied only to the regulation of the spray water temperature, as this gives sufficient control to enable the air humidity and temperature conditions to be kept constant.

The automatic control is through a thermostat made with a long stem which projects into the spray chamber just behind the baffles, or eliminators. The operation of this thermostat opens, or closes, a small air valve, which in turn causes an air-operated water valve to open or close. This water valve by-passes, as may be required, more or less of the spray water through the enclosed heater, so that the spray temperature is raised or lowered. The compressed-air supply for this control is obtained from a small single-stage single-cylinder air compressor, driven from the same motor which drives the circulating pump. It is indicated in plan, in Fig. 14, but the scale is, of course, rather small. The front of the thermostat and the air pipe connections can be seen in Fig. 11. The thermostat is directly below the indicating thermometer.

The operation of the automatic dew-point control depends on the fact that the air behind the eliminators is always saturated, so that the temperature is a measure of the humidity. If, while the apparatus is working, the outside temperature rises, the temperature of the air passing the thermostat, and the percentage of moisture it carries, would rise. If this condition persisted, the result would be that the air inside the building would become both too hot and too moist. The result of any rise of temperature is however an immediate operation of the thermostat, so that the temperature of the spray water would at once fall, and consequently less heat would be added to the air, and matters would adjust themselves to the original conditions. In the event of the outside temperature falling, the apparatus would operate to add more heat to the air. These changes operate very rapidly, and the conditions inside the building are maintained to all intents and purposes absolutely constant. We have said that the air behind the eliminators is saturated, but it does not enter the building in this state, since the temperature is raised, with a consequent fall in percentage humidity, by the action of the reheating coils in the discharge duct.

As already stated, the tempering and re-heating coils are not controlled automatically, but the control on the jets is sufficient to maintain constancy of conditions over long periods, and we understand the plant runs for weeks at a time without hand adjustment. All controls are, of course, capable of adjustment to allow for settings to suit seasonal variations. The various heaters are supplied from low-pressure hot-water boilers which were installed in the building while it was in occupation by the Government during the war. The system is fitted for pump circulation, and supplies the various radiators throughout the building in addition to the heaters. As already explained, extraction fans are fitted for the courts, and the normal method of working is for the conditioning plant to supply clean, warmed and conditioned air to the lower parts of the courts and the extraction fans to remove air from above. Secondary extraction is fitted in the case of Courts Nos. 1 and 2, to remove dust-laden air from near the floor. Normally, no windows are open, and as cleaned air only enters, a remarkably good atmosphere is maintained with a complete absence of dust and dirt other than that carried in by the persons attending the courts. This is dealt with as explained above.

It is particularly worthy of note that the two photographs from which Figs. 1 and 2 were prepared were taken while London was enveloped in a very dense fog.

The following table shows the excellent cooling results obtained during the recent extremely hot spell. It is obtained from the records of the heating apparatus attendant at the Sessions House.

Date.	Time.	Outside Temperature	Inside Court Temperature	Remarks.
1921.		Deg. F.	Deg. F.	
24th June	2.0 p.m.	86	68	Court crowded.
"	4.0 p.m.	90	70	
6th July	2.0 p.m.	90	66	Court fairly crowded.
"	4.0 p.m.	90	66	
7th July	2.0 p.m.	88	66	Court crowded.
"	4.0 p.m.	90	67	

In conclusion we must thank Mr. C. T. G. Hooper, Chief Engineer of the Buffalo Forge Co., for conducting us over this interesting installation. Mr. Hooper was responsible for the design of the plant from the contractors' side.

THE CONSTITUTION AND AGE-HARDENING OF THE ALLOYS OF ALUMINIUM WITH MAGNESIUM AND SILICON.*

By D. Hanson, D.Sc., Member, and Marie L. V. Gayler, M.Sc., Member. (From the National Physical Laboratory, Teddington.)

The research described in this paper forms part of an extensive investigation on aluminium alloys, carried out in the Metallurgy Department of the National Physical Laboratory under the direction of Dr. W. Rosenhain, F.R.S., the results of which have been collected together in the "Eleventh Report to the Alloys Research Committee." An abridged account of the results of the present research has been included in that Report, and a complete account is now published, for the first time, in this paper.

Introduction.—Some aluminium alloys possess the property of gradually hardening and becoming stronger after certain forms of heat treatment. If these alloys are heated to a temperature somewhat below their solidus (usually about 500° C.), and are subsequently rapidly cooled, it is found that immediately after such treatment they are relatively soft, but that in the course of a few days the hardness and tensile strength increase. This increase in hardness is fairly rapid at first, and gradually becomes slower, being practically complete after a few days. This phenomenon was first discovered by Wilm, who, as a result of his researches developed the alloy to which the name of "duralumin" has been given. This alloy usually contains 3 per cent. to 5 per cent. copper, about 0·8 per cent. manganese, and 0·5 per cent. magnesium. Wilm makes no reference to the other elements, mainly iron and silicon, which presumably enter this alloy as impurities in the aluminium.

In a series of preliminary experiments made about six years ago by one of the present authors, it was sought to determine which of the many elements contained in this alloy was responsible for the property of hardening by ageing after quenching, and it was found that when small quantities of both magnesium and silicon were present, very considerable hardening of the alloy by quenching could be obtained. When only very little silicon was present, copper, manganese, zinc, and iron, either alone or in the presence of 0·5 per cent. magnesium, did not confer appreciable hardening properties, nor were these found when either silicon or magnesium occurred alone in the alloy. These observations suggested that interest centres in the simultaneous presence of silicon and magnesium. It was decided, therefore, to undertake an investigation into the alloys of aluminium with silicon and magnesium, with a view to ascertaining the conditions under which hardening takes place.

Constitution of the Binary Systems.—As a preliminary to further investigation the binary systems, aluminium-magnesium and aluminium-silicon, were investigated.

The constitution of the alloys of aluminium and magnesium has already been described by the present authors. The equilibrium diagram is reproduced in Fig. 1.

The alloys of aluminium and silicon have been investigated by Roberts and Franckel. These investigators, however, did not determine the solubility of silicon in aluminium in the solid state. This determination has now been carried out and the results are represented in Fig. 2, which shows the constitution of the aluminium alloys containing up to 20 per cent. of silicon. Aluminium and silicon form a simple eutectiferous series, the eutectic containing 10·5 per cent. silicon and the eutectic temperature being 570° C. Aluminium will hold in solid solution 1·5 per cent. silicon at the eutectic temperature, and this solubility appears to be little, if any, less at lower temperatures.

Fig. 1.

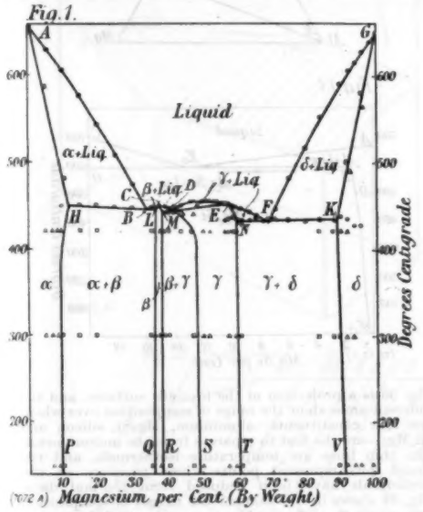


Fig. 2.

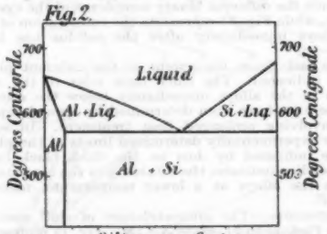
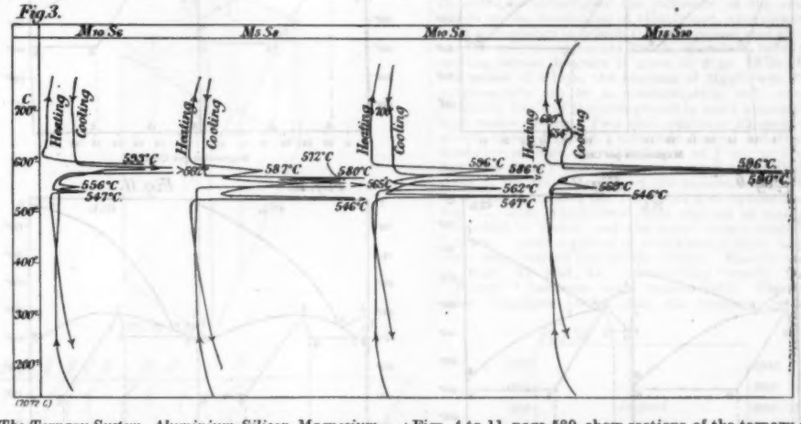


Fig. 3.



The Ternary System, Aluminium-Silicon-Magnesium.—For the purposes of the present investigation only a small portion of the complete system has been examined, namely, that portion containing alloys whose magnesium content extends up to 35 per cent., and whose silicon content extends up to 11 per cent.

Experimental Methods.—The experimental methods are in general similar to those which have been used in the investigation on the aluminium and magnesium alloys referred to above. Heating and cooling curves have been taken on 62 alloys. These alloys may be arranged in seven different groups; in each group the silicon content was kept constant, while the magnesium content was increased, usually in steps of 5 per cent. from 0 per cent. to 35 per cent.

The materials used were the purest that could be obtained, and analyses are given in an appendix to the paper. Silicon was added to the alloys in the form of an aluminium-silicon alloy containing about 20 per cent. silicon. In this rich alloy about 1 per cent. of iron was present as an impurity; this was probably derived from the silicon with which the alloy was made up, and, while undesirable, is probably without serious effect, except perhaps in the alloys rich in silicon.

Most of the alloys were prepared by first melting the aluminium, and afterwards adding the aluminium-silicon alloy, and then the magnesium, the latter being added as late as possible before pouring the metal. It is essential in this operation to avoid over-heating the alloy at any time, since when much magnesium is present it is liable to become ignited and burn vigorously. The molten alloys were poured partly into previously-prepared alumina-lined crucibles for the purpose of taking heating and cooling curves, and partly into metal moulds to provide chill castings of small structure, which could subsequently be used for experiments involving heat treatment of the solid alloys. The alloys rich in magnesium and silicon could not be prepared in this manner, since it was found that during solidification in the crucible, referred to above, a large volume of gas was evolved while the metal was becoming solid, and in many cases this gas caused the metal to swell up and froth over the sides of the crucible; other methods of casting had, therefore, to be adopted. In the first place, the alloys were made up by using, as the basis materials, aluminium-silicon and aluminium-magnesium alloys of low-melting point; by this means it was possible to prepare many of the alloys without having to raise the material to a temperature as high as the melting point of pure aluminium, and burning was by this means eliminated or considerably reduced. In the second place, the ingots required for cooling curves were obtained by re-melting the alloys prepared as above in the cooling curve crucibles in an evacuated furnace tube, and allowing them to cool out of contact with gases. After the ingot had been obtained the top of the crucible was closed by luting on a lid, and a thermal curve was also carried out *in vacuo*. This method was quite satisfactory, except in the cases of a few alloys containing large amounts of silicon and magnesium, in which cases a flux was used.

An appendix contains a list of the alloys prepared both for the determination of heating and cooling curves and for the investigation of the solid solubilities and mechanical properties of the alloys, together with their analyses. The authors are greatly indebted to Mr. P. Ward, B.Sc., and Miss M. Coade, B.Sc., for carrying out these analyses.

Nomenclature.—The alloys used have all been given distinguishing marks, which also indicate their intended composition. In all cases the letters M and S are used to indicate magnesium and silicon respectively, and the numbers which follow these letters indicate the percentage of each metal. The alloy M_{20} S_8, for example, indicates an alloy containing 20 per cent. magnesium and 8 per cent. silicon. This notation must be distinguished from that used to indicate chemical combination of the metals to form intermetallic compounds, in which definite chemical symbols are used, *e.g.*, Al_3Mg_2 and Mg_2Si.

Results of Thermal Curves.—The arrest points obtained on the heating and cooling curves (inverse rate method) are indicated in an appendix to the paper. Those arrest points which are followed by a query in this appendix are indicated by very small irregularities in the thermal curves, and it is very doubtful whether they represent genuine arrest points in the alloys themselves.

Fig. 3 shows a number of typical thermal curves.

Figs. 4 to 11, page 520, show sections of the ternary constitutional model, of series of alloys of constant silicon content, together with the thermal data on which they are based. Fig. 4 is a portion of the diagram of the binary aluminium-magnesium system. The liquidus line A B represents the separation of primary aluminium from the liquid, while along the line D B a eutectic of aluminium and Al_3Mg_2 is formed. The addition of silicon brings about a complete alteration of the diagrams; the section shown in Fig. 5 represents alloys containing 1 per cent. of silicon. A new series of arrest points appears, indicated by the line G H. In Fig. 6, representing alloys containing 2 per cent. of silicon, indications of further arrests are found, and another portion of the liquidus surface, H L, appears in section. These new transformations of the alloys exist throughout all the sections examined, though the shape of the reaction lines in the different sections becomes modified with increasing silicon content. For example, the line G H in Fig. 5 slopes downward from the point G. In Fig. 6 there are indications that this reaction line has a maximum point at about 3 per cent. of silicon; in Fig. 7 the maximum on this reaction line is well marked, while a definite horizontal arrest, P O Q, meets this line (G H) at the point O. As the silicon content increases, the maximum point G, on the line O G M, corresponds to alloys of increasingly high magnesium content, while the horizontal arrest at P O Q, becomes more marked and extends over a wider range in the sections. The line N D, which is common to all the sections, occurs at a constant temperature of approximately 450 deg. C., which temperature is almost identical with that of the aluminium–Al_3Mg_2 eutectic. There is every reason to suppose that this reaction at 450 deg. C. is due to the formation of a ternary eutectic, the melting point of which is not measurably different from the eutectic of the binary aluminium-magnesium series.

The line A H in all these sections represents the separation from the liquid of crystals of aluminium containing magnesium and silicon in solution; the line H L represents the separation of primary crystals of another constituent, which has a very characteristic appearance under the microscope. It is visible in unetched samples, in which it appears in the form of iridescent blue crystals. This constituent is strikingly

* Abstract of paper read before the Institute of Metals, at the Birmingham Meeting, September 22, 1921.

similar in appearance to one which has been described by Vogel as occurring in the alloys of magnesium and silicon, having the formula Mg_2Si, and it appeared probable that the two constituents were identical. Confirmation of this identity has been obtained by making up a series of alloys whose compositions are represented along the line A M, Fig. 12. In these alloys the ratio of magnesium to silicon content is that of the compound Mg_2Si, and such alloys may be regarded as belonging to a binary system aluminium–Mg_2Si, if such a system exists. A number of cooling curves has been taken of alloys belonging to this series, and the results are plotted in Fig. 13. It is found that the alloys used belong to what is essentially a binary system, consisting of the liquidus curves A E_3 and E_3C, and a constant temperature eutectic line N O. The arrest points indicated on this diagram at the temperature of about 550 deg. C. are extremely small and almost certainly represent the formation of traces of ternary eutectic, produced either through slight deviations from the intended composition or through lack of complete equilibrium during solidification. The microstructures of these alloys are also characteristic of a binary system; Figs. 14, 15 and 16, Plate XXIX, represent three of the alloys used and are typical of alloys of a simple binary eutectic series, with the sole exception that a trace of ternary eutectic is occasionally observed; such can be seen in one corner of Fig. 16. The dark constituent on these photographs is the bluish constituent referred to above. The evidence points very strongly to complete identity between the bluish compound and the compound Mg_2Si, and in all that follows this identity is accepted.

Referring to the sections shown in Figs. 4 to 11, the line O G M represents the separation of a complex consisting of aluminium solid solution and the compound Mg_2Si. The maximum point G in each section corresponds to an alloy in which the ratio of magnesium to silicon is the same as that in the compound Mg_2Si, that is, to alloys whose compositions fall on the line A M in Fig. 12. Furthermore, solidification appears to be complete at this temperature in these alloys. The slope of the line O G M on either side of the point G indicates that the reaction temperature is lowered by the presence of excess of either magnesium or silicon, in much the same way as the melting point of a pure metal is lowered by the addition of another element. The line G O meets the line F O, which slopes downwards from the point F, and represents the separation of a complex of aluminium and silicon. The point O occurs at a fixed temperature throughout the series, the temperature of the reaction line P O Q, which represents the separation of a ternary eutectic of aluminium Mg_2Si, and silicon. Between the lines G O and O Q, a binary complex of aluminium and Mg_2Si separates continuously; between the lines F O and O P, the binary complex of aluminium and silicon separates. In the same way the line N D lies in a horizontal plane in the system, which represents the separation of a ternary eutectic of aluminium, Mg_2Si, and Al_3Mg_2.

The solidus of these sections is represented by a broken line, F P O Q G D N.

The positions of the points P, Q, and D, under equilibrium conditions, is not indicated by the thermal curves, since complete equilibrium is never attained under such relatively rapid rates of cooling. To determine their positions, suitable alloys have been annealed for long periods at suitable temperatures, and have subsequently been examined by the microscope. Full details of these experiments are given in an appendix.

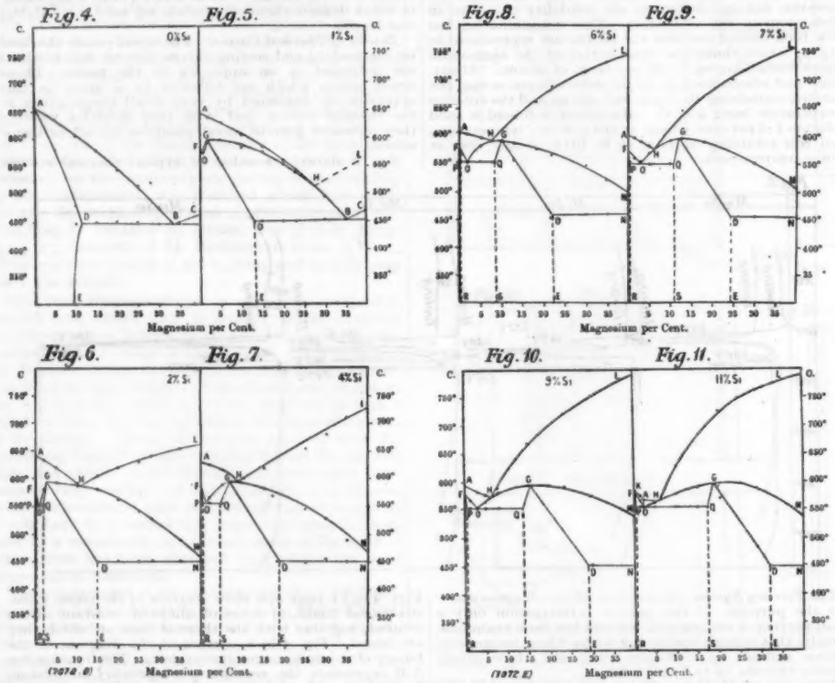
Constitutional Model.—The data obtained from these sections have been combined to form an equilibrium model, which represents simultaneously the effect of variations of composition and temperature on the constitution of the alloys. A photograph of such a model, constructed of wire in the manner which is now well known, is shown in Fig. 28. This, however, is somewhat complicated, and the photograph does not lend itself readily to detailed explanation, although the model itself is well suited for that purpose. A number of diagrams in perspective have therefore been prepared in which the various surfaces and phase boundaries have been especially indicated by different methods of shading. Fig. 29, page 521, which shows one of these diagrams, represents the liquidus surface of the ternary system over the range of composition investigated. This consists of four different surfaces, of which two, the surfaces E_2G S and E_1H M, representing respectively the surfaces at which silicon and Al_3Mg_2 begin to separate, are very small. The remaining surfaces are A E_2G B $E_3E_4E_1$ and D C B E_3E_4H, which intersect along the line B E_3E_4 and form a valley which has a maximum point at E_3. The first of these surfaces represents the beginning of the separation of aluminium containing dissolved silicon and magnesium, while the other represents the points of first separation of the compound of silicon and magnesium, having the formula Mg_2Si. The common line of intersection, B E_3E_4, represents points at which a eutectic complex of these two constituents begins to separate. These surfaces represent the first stages in the solidification of these alloys.

The second stage of solidification is shown in Fig. 30. This shows three surfaces, representing the separation of three different binary complexes. The surface K L T R slopes downwards from the binary eutectic line K L, and represents the beginnings of the separation of the aluminium-silicon complex. The surface P Q V U, sloping downwards from the binary eutectic line P Q, represents the separation of the aluminium–Al_3Mg_2 complex. The surface R T O F V U N is of more complicated shape. It slopes downwards on either side of the horizontal line N O, which lies wholly within the surface. On the one side it meets the aluminium-silicon complex surface in the line R T, while on the other side it meets the aluminium–Al_3Mg_2 complex in the line U V. This ridge-shaped surface represents the upper limit of the separation of a complex of aluminium and the compound Mg_2Si, which in the binary system aluminium–Mg_2Si (at the line N O) is a true eutectic; its intersections with the other two surfaces, the lines R T and U V, are horizontal and lie in the two ternary planes which the system possesses, and which are shown in the next section.

Fig. 31 represents the end of the solidification (or solidus) of the alloys. This consists of seven distinct surfaces, and completely covers the whole range of composition in that part of the alloy system under investigation. The surface K L Z R represents the end of the separation of the binary complex of aluminium and silicon, and alloys over this range of composition are entirely solid after the separation of this complex is complete. The horizontal plane R Z W represents the separation of a ternary eutectic of aluminium, silicon, and Mg_2Si, the two surfaces N O W R and N O Y U represent the solidus of the aluminium–Mg_2Si complex, and have the same ridge-shaped formation as has the upper limit of the separation of this body. It may be noted at this stage that the line N O is common to both the upper and lower limits of the separation of the aluminium–Mg_2Si complex; in other words, along this line this complex is strictly a eutectic, separating at a constant temperature, and not over a range of temperature. The points G shown in the different diagrams in Figs. 5 to 11 are points on this line N O. The surface N O W R meets the aluminium-silicon-Mg_2Si ternary eutectic plane in R W. The surface N O Y U meets another ternary eutectic plane in U Y. This latter plane, U Y X J, represents the separation of a ternary eutectic consisting of aluminium, Al_3Mg_2, and Mg_2Si. The surface P Q J U represents the end of the separation of the binary complex of aluminium and Al_3Mg_2, and intersects the corresponding ternary eutectic plane in U J. Finally, the complicated surface A K R N U P, which slopes steeply from the point A, represents the solidus of the aluminium-rich solid solution containing dissolved silicon and magnesium.

Fig. 32 is another diagram showing the solidus surface when viewed from near the aluminium corner. This figure illustrates particularly well the ridgelike shape of the solidus of the aluminium Mg_2Si complex, of which the eutectic horizontal line NO forms the crest. The solidus of the aluminium-rich solid solution is not drawn in this figure.

Figs. 33, 34 and 35 show projections of the different surfaces of separation on the horizontal base of the model.



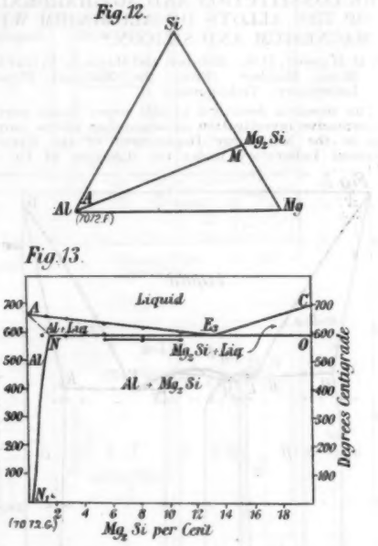


Fig. 33 is a projection of the liquidus surfaces, and the different areas show the range of composition over which the four constituents—aluminium, Mg_2Si, silicon and Al_3Mg_2—are the first to separate from the molten metal. The thin lines are temperature isothermals, and the round dots represent points whose positions on the isothermals have been deduced from thermal data. Fig. 34 shows in like manner the ranges of composition over which the different binary complexes of the system separate, while Fig. 35 represents the constitution of the solid alloys immediately after the solidus has been passed.

In the last figure the extent of the different phase fields is indicated. The thick lines refer to the constitution of the alloys immediately below the solidus, and these lines have been determined by special experiments involving prolonged heat treatment. In some cases the experimentally determined limits of the phase fields are indicated by dots on the thick black lines. The dotted line indicates the solubility of the constituent Mg_2Si in the alloys at a lower temperature, namely, 150 deg. C.

Microstructure.—The microstructure of chill castings shown in Figs. 17 to 21, Plate XXIX. Fig. 17 represents the alloy M_8S_2, consisting of primary crystals of aluminium and a binary eutectic of aluminium and Mg_2Si; Fig. 18, from the alloy $M_{10}S_2$, shows primary crystals of aluminium, binary eutectic consisting of aluminium and Mg_2Si, and ternary eutectic of aluminium, Mg_2Si, and Al_3Mg_2 (the larger dark etching portions are Al_3Mg_2); it will be noticed that in each of these cases the aluminium solid solution occurs as a primary separation. Fig. 19 represents the alloy $M_{20}S_2$; the constituents in this case are the same as in Fig. 18, but the primary separation now consists of Mg_2Si. The same type of constitution is found in Figs. 20 and 21, which represents respectively the alloys $M_{25}S_2$ and $M_{30}S_2$; in these the proportion of Mg_2Si remains practically constant, while the amount of Al_3Mg_2 (half-tone in photographs) increases with the magnesium content. The microscopic appearance of these alloys agrees with the interpretation given to the lines in Fig. 6, to which section they all belong; the microscopic appearance of the different constituents is indicated more clearly in Figs. 22 to 27, Plate XXX. These specimens were taken from the cooling curve ingots, and possess a larger and more clearly-defined structure. Fig. 22 represents the alloy M_8S_4 and shows clearly the primary separation of aluminium solid

solution, the binary eutectic of aluminium and Mg_2Si (coarse), and the ternary eutectic of aluminium, Mg_2Si, and silicon (fine). Fig. 23 represents the alloy $M_{10}S_4$. The composition of this alloy is very close to that of the simple binary eutectic of Mg_2Si and aluminium, of which it almost entirely consists. Fig. 24 represents the alloy M_5S_3, and shows primary crystals of aluminium, binary eutectic of aluminium and Mg_2Si, and ternary eutectic of aluminium, Mg_2Si and silicon. Fig. 25 represents the alloy $M_{10}S_3$; this consists of primary crystals of Mg_2Si, a large proportion of binary eutectic of aluminium and Mg_2Si, and a small amount of ternary eutectic of aluminium, Mg_2Si and silicon. The unusual skeleton-like form of the crystals of Mg_2Si will be observed; these curious crystals were observed quite frequently in these alloys. Fig. 26 represents alloy $M_{15}S_2$; in this case primary crystals of Mg_2Si and binary eutectic of aluminium and Mg_2Si occur, and it will be observed on reference to Fig. 12 that the point representing the composition of this alloy is close to the line A M. Fig. 27 shows an unetched section of the alloy $M_{35}S_{10}$, and illustrates characteristic forms of the compound Mg_2Si. The white matrix consists of aluminium and Al_3Mg_2, but these constituents can only be distinguished in etched specimens.

Solubility of Mg_2Si in the Alloys.—It has been shown in the introduction that the presence of both magnesium and silicon confers upon aluminium the property of hardening after quenching from a high temperature. The occurrence of a definite compound of these two elements in the alloys suggested very strongly that this compound played an important part in conferring the hardening properties. A careful determination of the solubility of this compound under all circumstances was therefore undertaken.

In the first place, the binary system aluminium—Mg_2Si—was investigated, and the solubility of Mg_2Si in aluminium containing no excess of either magnesium or silicon was determined. The method adopted was that which has already been described in an investigation into the constitution of the alloys of aluminium and magnesium; samples were heated for a prolonged period at a temperature slightly below the solidus, in order to obtain uniformity of composition throughout the solid solution, and were afterwards cooled at an extremely slow rate to different temperatures, from which they were quenched. They were then examined under the microscope. The solubility of Mg_2Si in aluminium is indicated in Fig. 36, in which the experimental results on which the curves are based are indicated, the triangles showing points at which the alloys are homogeneous, and the squares representing points at which they are duplex. It will be observed that whereas about 1·6 per cent. Mg_2Si (1 per cent. magnesium, 0·6 per cent. silicon) are held in solution at a temperature of 580 deg. C., the solubility has fallen to about 0·9 per cent. at 350 deg. C., and to not more than 0·5 per cent. at 30 deg. C. It is probable also that the solubility at 30 deg. C. is appreciably less than that indicated, because the rate of diffusion at such a low temperature is extremely small, and it is doubtful whether equilibrium has been obtained, even with the extremely slow rates of cooling which were adopted. Fig. 37, page 522, shows the microstructure of the alloy containing 1·35 per cent. Mg_2Si after quenching from 581 deg. C.; at this temperature it consists entirely of homogeneous solid solution. The microstructure after cooling slowly to 30 deg. C. is shown in Fig. 38, in which small crystals of Mg_2Si can be seen.

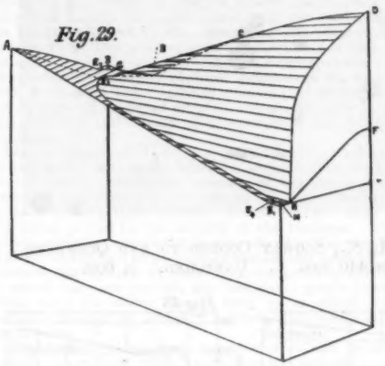
Experiments were made in order to determine the effect on this solubility of excess of both magnesium and silicon. The effect of excess of magnesium is to cause a rapid lowering of the solubility of Mg_2Si at high temperatures, the actual solubility curve being indicated in Fig. 35. For example, in the presence of an excess of only 0·7 per cent. magnesium, the solubility of Mg_2Si is reduced from 1·6 per cent. to 1·1 per cent. An increase of the magnesium content to 5 per cent. renders Mg_2Si practically insoluble. With still higher magnesium contents, for example, up to 30 per cent. magnesium, Mg_2Si is found in the alloys as a separate constituent under all conditions, even when the silicon content is only 0·2 per cent.; it would therefore appear that Mg_2Si is also insoluble in the compound Al_3Mg_2.

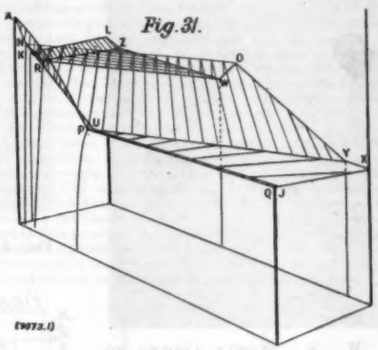
Excess of silicon, on the other hand, appears to have very little effect on the solubility of the compound Mg_2Si. The solubility at both high and low temperatures appears to be slightly increased, though the effect is not very marked.

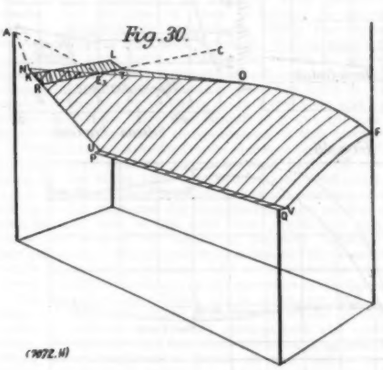
Figs. 39 and 40 represent respectively alloy $M_{12}S_{0\cdot2}$ and $M_{12}S_{0\cdot4}$, quenched from 440 deg. C. The presence of relatively large quantities of Mg_2Si can be seen in Fig. 40. Fig. 41 shows the alloy $M_{50}S_{0\cdot4}$ quenched from 440 deg. C. The large amounts of Mg_2Si present in this sample indicate that the compound is practically insoluble in the aluminium phase of this alloy.

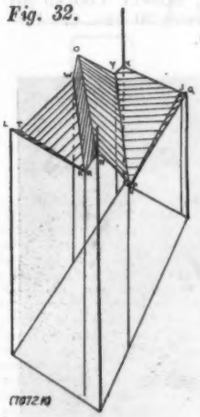
In the same way the solubility of silicon and of Al_3Mg_2 have been determined; the results of the experiments are incorporated in the constitutional diagram.

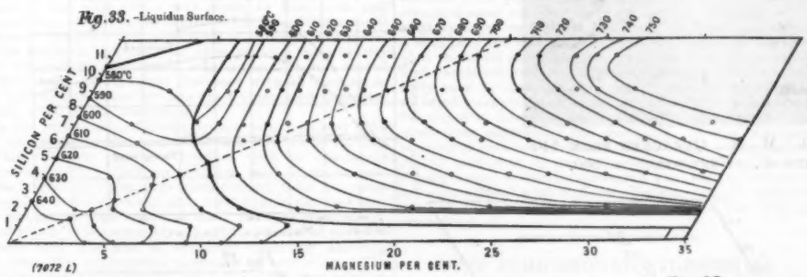
The Heat Treatment and Age-Hardening of the Alloys.—In order to investigate the influence of the compound Mg_2Si on the hardening of aluminium, experiments have been undertaken in which this compound and aluminium are the only constituents which, therefore, belong to the system, whose diagram is given in Figs. 13 and 36. In this series of alloys, the amount of Mg_2Si was increased progressively up to a concentration well above the solubility limit of this compound in solid aluminium at a high temperature. Two chill castings of each of these alloys were prepared. One was forged hot from 1 in. diameter as cast, to a thickness of $\frac{3}{4}$ in., and used for hardness tests; the other was forged and rolled into a strip $\frac{1}{10}$ in. thick and used for tensile tests. Samples were then annealed for 1 hour at a temperature of 500 deg. C., after which treatment one set of samples was quenched in water, and the other slowly cooled in the furnace. After a period of about seven days, mechanical tests were carried out on the alloys. Results are shown in Figs. 42 and 43, representing tensile tests and "Brinell" hardness tests respectively. The study of these diagrams shows that the increase in hardness produced during ageing of the alloys after quenching, rises progressively with the amount of Mg_2Si present in the alloy, until the limit of solubility is reached, beyond which the total increase in hardness remains practically constant. It would therefore appear that the extent of the age-hardening which takes place is roughly proportional to the amount of magnesium silicide in solution at the moment of quenching. Further to confirm this view, other experiments were undertaken in a similar manner on other alloys of the ternary system—not necessarily belonging to the binary aluminium–Mg_2Si system, and therefore lying to either side of the line N O (Fig. 31). The alloys examined are indicated in Figs. 44 and 45, and the results of the tests are also indicated in these figures and in Figs. 46 and 47. Here, again, in each of the series of alloys examined it is found that the hardness due to ageing increases with the amount of

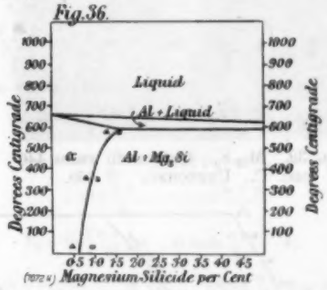


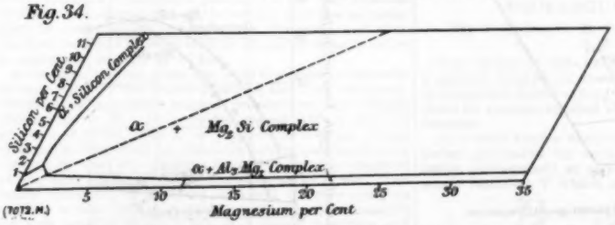


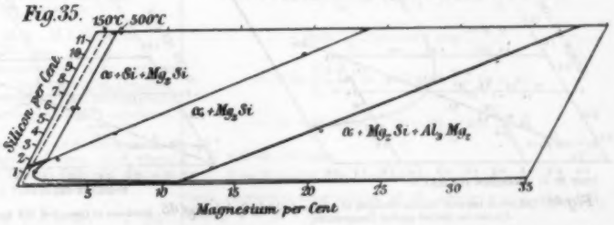












THE CONSTITUTION AND AGE-HARDENING OF ALUMINIUM ALLOYS.

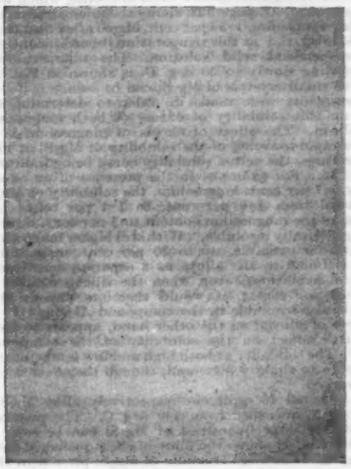


Fig. 37. $M_{0·85}$ $S_{0·5}$ Quenched from 581 deg. C. Unetched. × 1000.

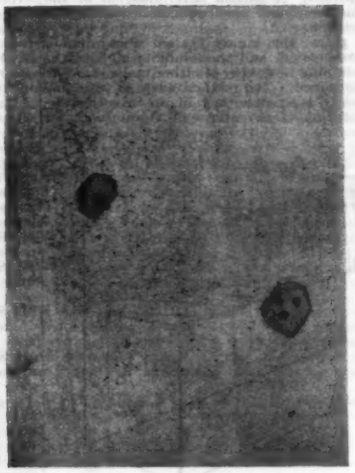


Fig. 38. $M_{0·85}$ $S_{0·5}$ Slowly Cooled to and Quenched from 30 deg. C. Unetched. × 1000.

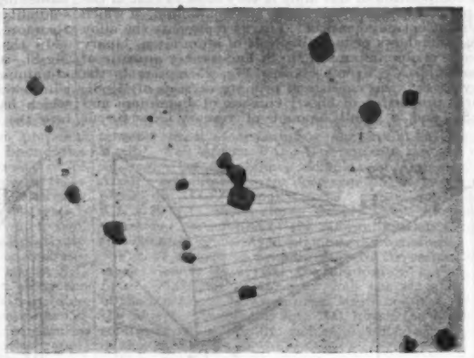


Fig. 41. M_{30} $S_{0·4}$ Slowly Cooled to and Quenched from 440 deg. C. Unetched. × 600.

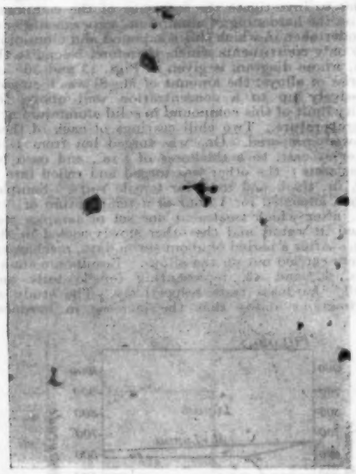


Fig. 39. M_{12} $S_{0·2}$ Quenched from 440 deg. C. Unetched. × 600.

Fig. 40. M_{12} $S_{0·4}$ Quenched from 440 deg. C. Unetched. × 600.

Fig. 42.

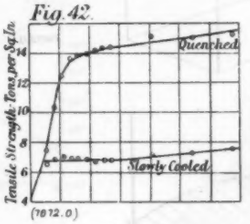


Fig. 43.

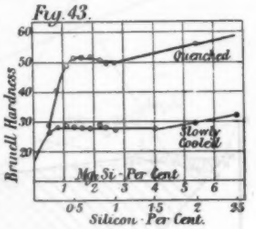
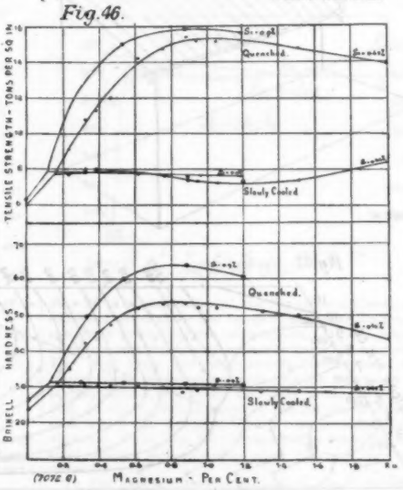


Fig. 46.



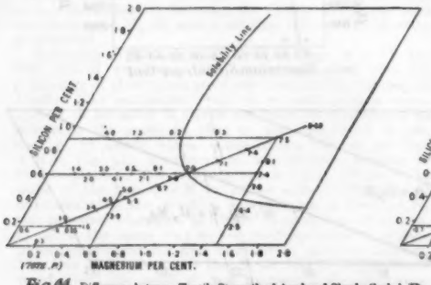


Fig. 44. Difference between Tensile Strength of Aged and Slowly Cooled Specimens plotted against Composition.

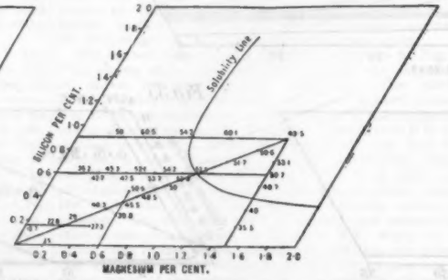
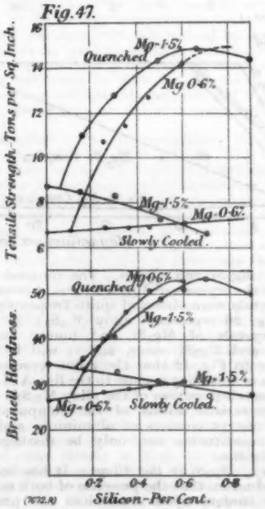


Fig. 45. Hardness of Quenched and Aged Alloys plotted against Composition.

Fig. 47.



Mg_2Si in solution up to the limit of solubility at the quenching temperature. In Figs. 44 and 45 the limit of solubility at high temperatures is indicated by the full black line, and it will be observed that the alloys examined reach a maximum hardness in the neighbourhood of this solubility line.

The results which are summarised in these diagrams leave little doubt that the ageing of these alloys is due to the fact that, on quenching, magnesium and silicon are retained, probably in solution, in an unstable condition, from which they tend to revert to a more stable form. It would appear that the gradual hardening is due to the changes which occur in the alloy as the result of the tendency to the formation of separate crystals of aluminium and Mg_2Si, existing side by side in the alloy. That the separation of particles of Mg_2Si of large size does not take place is established by microscopic examination and further confirmed by the mechanical tests, since an alloy in this condition has a tensile strength and hardness considerably less than that of the quenched alloy immediately after quenching and before ageing takes place. An age-hardened alloy appears to reach a hard metastable state, which is either permanent or at least persists for a period of many years. It is possible that this condition is attained when the precipitated particles have reached a definite size (or exist within certain limits of size), and that a condition of increased hardness is associated with this particular degree of dispersion.

In conclusion, the authors wish particularly to express their indebtedness to Dr. W. Rosenhain, F.R.S, for his continued interest and encouragement during the course of this research.

RELATION OF POWER PRESSES AND DIES TO THE AUTOMOBILE INDUSTRY.*

By HENRY J. HINDE, TOLEDO, OHIO.

THE art of producing sheet-metal stampings from a flat sheet while cold has made marked progress in recent years, and many articles are now made of sheet metal which were formerly produced by casting or forging, or in a lathe, milling machine, drill press or at the bench.

Forming and stamping operations especially have in many classes of work become very complex, and the art of drawing sheet metals, stimulated by the enormous demand of the automobile industry in particular, calling for most intricate shapes, has reached a state of perfection hardly imagined possible a few years ago. The results achieved by the ingenuity of the present-day press and die designers, and to no small degree also by the metallurgist, who comes into consideration through his improvements of the physical qualities of the metals used, are indeed revelations in economy of production, the strength of stamped articles, and the absolute interchangeability and beauty of appearance of the finished products.

The development of power presses, together with that of dies and special tools, has been so marked in the last twelve years, principally because of the demand for intricate stampings for the automobile trade, that it is believed a far greater advance has been made than at any other period in the history of the business. This development has not wholly been confined to the working of sheet metal, for, as previously stated, the demand for accurate duplication of parts and the great quantities in which they are desired, has resulted in power presses being used for sizing forged steel parts which were formerly finished by means of saddle milling and similar operations.

It has been found that manufacturers can produce greater quantities with much greater accuracy, and with such a reduction in machine shop production expense, by the use of what is known as knuckle-joint or cold-swaging presses, in sizing the finished working surfaces on these forgings, that a number of equipments have been installed for work on steering knuckles, brake levers, connecting rods and other similar forgings and castings. These presses are built in sizes capable of exerting a pressure up to 2,000 tons and over, and it is claimed that size limits of 0·001 in. can be successfully maintained in operations of this character.

Although this marked advance is due to the automobile industry more than to any other one factor in recent years, at the same time the economical production of motor cars was made possible solely on account of the ability of the press and die manufacturers to control successfully the flow of the cold sheet metal into certain forms and shapes, by means of properly constructed dies and presses of such power and design that wonderful results have been obtained. As an illustration of this a wire-wheel hub is shown in the accompanying figure.

This hub required a blank 16½ in. diameter and $\frac{5}{16}$ in. thick. Attention is called in particular to the numerous niches or pockets successfully formed into the circular shape, and also to the fact that the stamping was first drawn to a considerable depth at the narrow neck. The end of the neck or bottom of the stamping was then removed and this metal was made to flow back and expand to a considerable degree beyond its former small diameter without even stretching or thinning the metal in the reforming operations, thus proving conclusively how successfully the metal was controlled and forced to flow back into its larger diameter with an opening in the bottom much smaller than the former small diameter of the neck of the stamping.

In the production of brake drums, front and rear hubs and spoke flanges the conditions that have to be fulfilled by the dies are that the product shall be absolutely interchangeable; that no machine work shall be performed upon the stampings when coming from the press excepting some reaming and thread cutting, and that the strength of the material shall remain unimpaired. In addition, it is imperative that all cylindrical parts be smooth and true and of standard diameter, allowing less than the commercial tolerance of variation. The work involves a most careful planning of the inter-relation of the several operations, so that at no time the material shall be overstrained or reduced in thickness, and that the dies shall not be subjected to excessive wear in order to maintain uniformity of size.

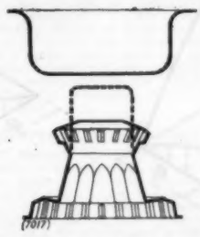
A straight-column press has been developed especially for such work by the Toledo Machine and Tool Company, which is of unusually rugged proportions and weighs about 145,000 lb. It is double-geared with a ratio of 40 : 1, and fitted with a very powerful friction clutch in combination with an effective brake and hand-lever control, so that the machine may be started or stopped at any part of the stroke of the slide up or down. The frame consists of four pieces—the bed, the two uprights and the crown—which are held together by four massive tie rods passing through the said crown, uprights and bed. When the frame is assembled these tie rods are heated. The nuts are then screwed home and the rods permitted to cool. In this manner, through the tendency of the rods to shrink, an enormous pressure is exerted by the rods upon the frame that renders the entire structure practically an integral one and brings all the working stress upon the tie rods.

Axle housings are made of steel plate up to $\frac{1}{2}$ in. in thickness, and the requirements are that the stampings be perfectly straight and flat, so that when the two halves of a housing are joined together by welding they form a perfect casing without warp. A powerful double-crank press developed for this purpose weighs about 95,000 lb. and is capable of forming and stamping cold at one blow axle-housing halves about 40 in. in length of steel plate up to $\frac{1}{2}$ in. in thickness, the blank having been cut previously to proper shape.

One modern form of toggle drawing and deep-stamping press, such as is used for making engine pans, radiators and other similar articles of the comparatively lighter gauges of metal, has two slides, an outer slide for clamping the blank and holding it while the work is being drawn, and an inner slide for doing the drawing, stamping and forming operation. Presses of this character are also made in the double-crank type with a considerable distance between the uprights, and weighing as much as 600,000 lb. Such presses are used for body forming, for making cowls, dashes, fenders, &c.

The forming of channels and side rails for automobile frames and similar requirements has resulted in the designing and building of special presses particularly adapted for this work. The side rails, for instance, are preferably first blanked in a double-crank press as much as 218 in. between the uprights. The largest sizes of these presses weigh in the neighbourhood of 500,000 lb.

The forming operations are performed in a specially designed press, the outstanding feature of which is that the operation is diametrically opposite that of the ordinary toggle drawing or deep-stamping double-action presses. The channel-forming press has a movement entirely mechanical that brings the tools down and at rest on a flat blank, or sheet, by means of a toggle motion, and in this position the machine is capable of a resistance pressure upward of 2,000 tons. While this first toggle movement is at rest, another movement is brought into play, forming up the sides of the channel or frame. The



machine in its operation completes the one cycle when the stamping lies on the face of the dies completely formed, with the result that the web, or bottom of the stamping, remains as flat as it was in the original sheet. In other words, the bottom or web of the channel is held perfectly flat during the operation. Several of these presses have been built and are in most successful operation. They weigh upward of 600,000 lb. each. One of these presses with five men will do the work of three hydraulic presses with fifteen men, to say nothing of the large force required to straighten the rails when hydraulic presses are used.

Still another interesting feature that the automobile trade has developed is the smoothing-out process for certain of its stampings, more particularly the tapered, stamped-steel radiator front or casing. Because of its slightly tapering form it was found difficult to produce a stamping for this piece so free from waves, or buckles, that it would show smooth over the finally enamelled and varnished surface. The requirements were successfully met by developing a set of tools to receive the finished stamping and allow an exceedingly small space for water to flow just inside of the stamping around the steel form supporting the stamping. It was necessary to exert a pressure of some 2,000 tons on the outer surface of the stamping to prevent seepage or leaking, and to supply water to the die through a ¾ in. pipe by means of an accumulator with sufficient force to smooth and iron out all of the unevenness and waves in the original stamping.

*Paper read before the American Society of Mechanical Engineers, at the Chicago Meeting, May 23 to 26, 1921.

TWO DIMENSIONAL STRESSES IN RECTANGULAR PLATES.*

By Professor C. E. INGLIS, M.A., M.I.Mech.E., A.M.Inst.C.E.

THE object of this brief communication is to outline a general analytical method for investigating the two dimensional distributions of stress set up in a rectangular plate by stresses applied along its edges in any arbitrary manner.

It is well known that in the case of two dimensional stress generated by such boundary forces, the three stress components at any point can be deduced from a single function V which satisfies the equation.

$$\frac{\partial^4 V}{\partial x^4} + 2\,\frac{\partial^4 V}{\partial x^2\,\partial y^2} + \frac{\partial^4 V}{\partial y^4} = 0 \quad . \quad . \quad (1)$$

written for short, $\nabla^4 V = 0$.

The two normal stresses and the shear stress at any part are then given by

$$R_x = \frac{\partial^2 V}{\partial y^2}, \qquad R_y = \frac{\partial^2 V}{\partial x^2}, \qquad S = -\frac{\partial^2 V}{\partial x\,\partial y}.$$

Particular functions of x and y can be obtained in any number to satisfy $\nabla^4 V = 0$, but in order to arrive at the function corresponding to any specified boundary condition a systematic method of procedure in the nature of harmonic analysis is essential.

On the assumption that $f(y) \sin n x$ is a solution, we find by substitution in equation (1) that $f(y)$ is of the form $(A + B y) \sinh n y + (C + D y) \cosh n y$ where A, B, C, D are independent constants.

Any value of V which is made up of terms of the character $\sinh n y \sin n x$, $y \sinh n y \sin n x$, or of corresponding terms obtained by interchanging sine with cosine, sinh with cosh, and x with y, satisfies the equation $\nabla^4 V = 0$.

In its relation to a rectangular plate bounded by the sides $x = \pm a$, $y = \pm b$ consider

$$V = \frac{P_n}{\frac{n\pi}{a}}\left[(y+b)\cosh\frac{n\pi}{a}(y-b) - (y-b)\cosh\frac{n\pi}{a}(y+b) - \frac{1}{\frac{n\pi}{a}}\left\{\sinh\frac{n\pi}{a}(y-b) - \sinh\frac{n\pi}{a}(y+b)\right\}\right]\cos\frac{n\pi x}{a}.$$

$$R_x = \frac{\partial^2 V}{\partial y^2} = P_n\left[\frac{n\pi}{a}\left\{(y+b)\cosh\frac{n\pi}{a}(y-b) - (y-b)\cosh\frac{n\pi}{a}(y+b)\right\} + \sinh\frac{n\pi}{a}(y-b) - \sinh\frac{n\pi}{a}(y+b)\right]\cos\frac{n\pi x}{a}.$$

$$R_y = \frac{\partial^2 V}{\partial x^2} = P_n\left[\frac{n\pi}{a}\left\{(y+b)\cosh\frac{n\pi}{a}(y-b) - (y-b)\cosh\frac{n\pi}{a}(y+b)\right\} - \sinh\frac{n\pi}{a}(y-b) + \sinh\frac{n\pi}{a}(y+b)\right]\cos\frac{n\pi x}{a}.$$

$$S = -\frac{\partial^2 V}{\partial x\,\partial y} = P_n\left[\frac{n\pi}{a}\left\{(y+b)\sinh\frac{n\pi}{a}(y-b) - (y-b)\sinh\frac{n\pi}{a}(y+b)\right\}\right]\sin\frac{n\pi x}{a}.$$

If n is an integer $S = 0$, when $x = \pm a$, and $y = \pm b$,

$$R_x = (-1)^n P_n\left[\frac{n\pi}{a}\left\{(y+b)\cosh\frac{n\pi}{a}(y-b) - (y-b)\cosh\frac{n\pi}{a}(y+b)\right\} + \sinh\frac{n\pi}{a}(y-b) - \sinh\frac{n\pi}{a}(y+b)\right]$$

at the boundaries $x = \pm a$

$$R_y = -P_n\left[\frac{2n\pi b}{a} + \sinh\frac{2n\pi b}{a}\right]\cos\frac{n\pi x}{a}$$

at the boundaries $y = \pm b$

By taking different values of n, any number of harmonic components required to represent the distribution of R_y along the edges $y = \pm b$ can be written down but each of these is paired with a corresponding hyperbolic component for R_x along the edges $x = \pm a$.

To disentangle the distribution of R_y along $y = \pm b$ from the distribution of R_x along $x = \pm a$, it is necessary to introduce another stress distribution corresponding to

$$V = \frac{Q_n}{\frac{n\pi}{b}}\left[(x+a)\cosh\frac{n\pi}{b}(x-a) - (x-a)\cosh\frac{n\pi}{b}(x+a) - \frac{1}{\frac{n\pi}{b}}\left\{\sinh\frac{n\pi}{b}(x-a) - \sinh\frac{n\pi}{b}(x+a)\right\}\right]\cos\frac{n\pi y}{b}.$$

From which it follows

$$R_x = -Q_n\left[\frac{n\pi}{b}\left\{(x+a)\cosh\frac{n\pi}{b}(x-a) - (x-a)\cosh\frac{n\pi}{b}(x+a)\right\} - \sinh\frac{n\pi}{b}(x-a) + \sinh\frac{n\pi}{b}(x-a)\right]\cos\frac{n\pi y}{b}.$$

$$R_y = Q_n\left[\frac{n\pi}{b}\left\{(x+a)\cosh\frac{n\pi}{b}(x-a) - (x-a)\cosh\frac{n\pi}{b}(x+a)\right\} + \sinh\frac{n\pi}{b}(x-a) - \sinh\frac{n\pi}{b}(x-a)\right]\cos\frac{n\pi y}{b}.$$

$$S = Q_n\left[\frac{n\pi}{b}\left\{(x+a)\sinh\frac{n\pi}{b}(x-a) - (x-a)\sinh\frac{n\pi}{b}(x-a)\right\}\right]\sin\frac{n\pi y}{b}.$$

If n is an integer.

$S = 0$ along the four edges $x = \pm a$ $y = \pm b$

and corresponding values of R_x along $x = \pm a$ and R_y along $y = \pm b$ are

$$R_x = -Q_n\left[\frac{2n\pi a}{b} + \sinh\frac{2n\pi a}{b}\right]\cos\frac{n\pi y}{b}$$

$$R_y = (-1)^n Q_n\left[\frac{n\pi}{b}\left\{(x+a)\cosh\frac{n\pi}{b}(x-a) - (x-a)\cosh\frac{n\pi}{b}(x+a)\right\} + \sinh\frac{n\pi}{b}(x-a) - \sinh\frac{n\pi}{b}(x-a)\right].$$

By taking different values of n, harmonic components for R_x along $x = \pm a$ can be written down in any number, each of these being paired with a hyperbolic component of R_y along $y = \pm b$.

These pairs of functions will be referred to as the Q components of R_x R_y, in contradistinction to the pairs

*Paper read before Section G of the British Association at Edinburgh, September 13, 1921.

previously obtained which will be called the P components.

Suppose it is required to determine the P and Q functions which correspond to given distributions of R_x and R_y along $x = \pm a$, $y = \pm b$ respectively.

The general procedure is as follows :—

Analyse the boundary distributions of R_x, R_y into Fourier series.

Suppose

$$R_x = A_1 \cos\frac{\pi y}{b} + A_2 \cos\frac{2\pi y}{b} + A_3 \cos\frac{3\pi y}{b} + \ldots$$

$$R_y = B_1 \cos\frac{\pi x}{a} + B_2 \cos\frac{2\pi x}{a} + B_3 \cos\frac{3\pi x}{a} + \ldots$$

If the boundary conditions have to be satisfied as far as the first six harmonic components are concerned, the first six P functions and the first six Q functions are then written down and analyzed up to the sixth harmonic. By equating together coefficients of corresponding harmonic components, twelve equations are obtained, by which the twelve coefficients $P_1, P_2 \ldots P_6, Q_1, Q_2 \ldots Q_6$ can be evaluated in terms of the known quantities $A_1, A_2 \ldots A_6, B_1, B_2 \ldots B_6$. In this way a function V is built up which at any rate satisfies the boundary conditions so far as the first six harmonic components are concerned. The number of components necessary to take into account must naturally depend upon the character of the boundary conditions specified.

If n is an integer $S = 0$ when $y = \pm b$ and $R_x = 0$ when $x = \pm a$

$$\begin{cases} R_y = -P_n\left[\dfrac{(2n+1)\pi b}{2a} + \sinh\dfrac{(2n+1)\pi b}{a}\right]\cos\dfrac{(2n+1)\pi x}{a} \text{ along the edges } y = \pm b \\ S = (-1)^n P_n\left[\dfrac{(2n+1)\pi}{a}\left\{(y+b)\sinh\dfrac{(2n+1)\pi(y-b)}{2a} - (y-b)\sinh\dfrac{(2n+1)\pi(y+b)}{2a}\right\}\right] \end{cases}$$

at $x = a$, and with its sign changed at $x = -a$

give a series of pairs of functions for R_y and S at the boundaries. These will be termed the P components.

To get independence between the distributions of R_y and S along their respective boundaries another set of pairs have to be obtained, and the general form of V giving rise to these Q functions is

$$V = \frac{Q_n}{n\pi}\left[(x+a)\sinh\frac{n\pi}{b}(x-a) + (x-a)\sinh\frac{n\pi}{b}(x+a)\right]\cos\frac{n\pi y}{b}$$

$$R_y = P_0 \cos\frac{\pi x}{2a}$$

$$S = -P_0\left[-0{\cdot}49211\frac{y}{a}\cosh\frac{\pi y}{2a} + 0{\cdot}53657\sinh\frac{\pi y}{2a}\right]$$

$$R_y = P_2 \cos\frac{5\pi x}{2a}$$

$$S = -P_2\left[-0{\cdot}00610\frac{y}{a}\cosh\frac{5\pi y}{2a} + 0{\cdot}00610\sinh\frac{5\pi y}{2a}\right]$$

$$R_y = -Q_1\left[0{\cdot}2658\frac{x}{a}\sinh\frac{\pi x}{a} - 0{\cdot}0956\cos\frac{\pi x}{a}\right]$$

$$S = Q_1 \sin\frac{\pi y}{a}$$

$$R_y = Q_2\left[0{\cdot}02346\frac{x}{a}\sinh\frac{2\pi x}{a} - 0{\cdot}0161\cosh\frac{2\pi x}{a}\right]$$

$$S = Q_2 \sin\frac{2\pi y}{a}$$

$$R_y = -Q_3\left[0{\cdot}00152\frac{x}{a}\sinh\frac{3\pi x}{a} - 0{\cdot}00120\cosh\frac{3\pi x}{a}\right]$$

$$S = Q_3 \sin\frac{3\pi y}{a}$$

Fig. 1. SHOWING VARIATION OF TENSION IN PLATE IN DIRECTION A.B.

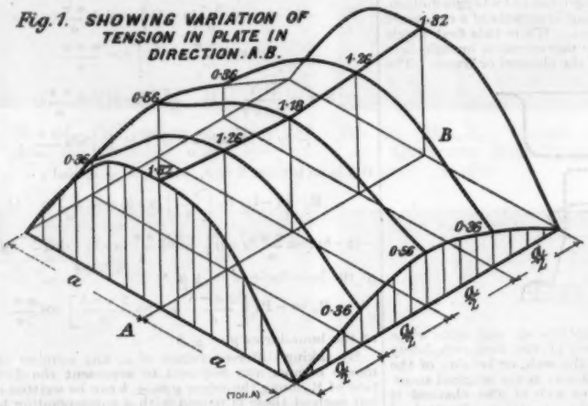


Fig. 2. SHOWING VARIATION OF TENSION IN PLATE IN DIRECTION C.D.

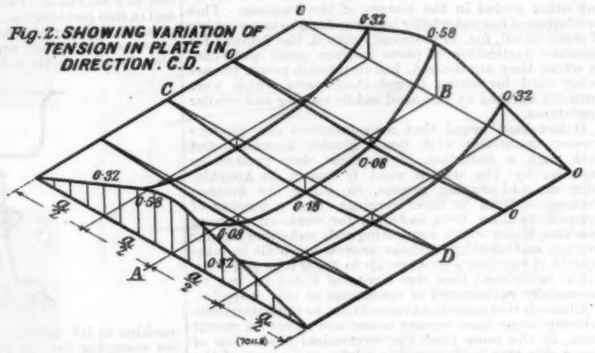
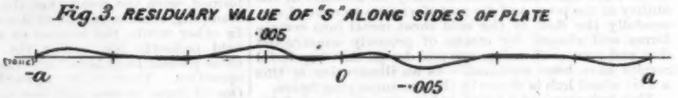


Fig. 3. RESIDUARY VALUE OF "S" ALONG SIDES OF PLATE



In the foregoing it has been tacitly assumed that R_x, R_y are even valued functions of x only. A slight modification in the form of V, which it is hardly necessary to write down at length, makes it possible to deal with perfectly general distributions of stress normal to the boundaries, provided, of course, that these distributions satisfy the general conditions of equilibrium for the plate.

As an alternative to the foregoing suppose the boundary conditions consist of an even valued distribution of R_y along the edges $y = \pm b$ accompanied by an odd valued distribution of S along the edges $x = \pm a$.

A general function of V corresponding to this case is

$$V = \frac{P_n}{\frac{(2n+1)\pi}{2a}}\left[(y+b)\cosh\frac{(2n+1)\pi(y-b)}{2a} - (y-b)\cosh\frac{(2n+1)\pi(y+b)}{2a} - \frac{1}{\frac{(2n+1)\pi}{2a}}\left\{\sinh\frac{(2n+1)\pi(y-b)}{2a} - \sinh\frac{(2n+1)\pi(y+b)}{2a}\right\}\right]\cos\frac{(2n+1)\pi x}{2a}.$$

$$R_x = P_n\left[\frac{(2n+1)\pi}{2a}\left\{(y+b)\cosh\right)\frac{(2n+1)\pi(y-b)}{2a} - (y-b)\cosh\frac{(2n+1)\pi(y+b)}{2a}\right\} + \sinh\frac{(2n+1)\pi(y-b)}{2a} - \sinh\frac{(2n+1)\pi(y+b)}{2a}\right]\cos\frac{(2n+1)\pi x}{2a}.$$

$$R_y = -P_n\left[\frac{(2n+1)\pi}{2a}\left\{(y+b)\cosh\frac{(2n+1)\pi(y-b)}{2a} - (y-b)\cosh\frac{(2n+1)\pi(y+b)}{2a}\right\} - \sinh\frac{(2n+1)\pi(y-b)}{2a} + \sinh\frac{(2n+1)\pi(y+b)}{2a}\right]\cos\frac{(2n+1)\pi x}{2a}.$$

$$S = P_n\left[\frac{(2n+1)\pi}{2a}\left\{(y+b)\sinh\frac{(2n+1)\pi}{2a}(y-b) - (y-b)\sinh\frac{(2n+1)\pi(y+b)}{2a}\right\}\sin\frac{(2n+1)\pi x}{2a}\right.$$

$$R_x = -Q_n\left[\frac{n\pi}{b}\left\{(x+a)\sinh\frac{n\pi}{b}(x-a) + (x-a)\sinh\frac{n\pi}{b}(x+a)\right\}\right]\cos\frac{n\pi y}{b}$$

$$R_y = Q_n\left[\frac{n\pi}{b}\left\{(x+a)\sinh\frac{n\pi}{b}(x-a) + (x-a)\sinh\frac{n\pi}{b}(x+a)\right\} + 2\cosh\frac{n\pi}{b}(x-a) + 2\cosh\frac{n\pi}{b}(x+a)\right]\cos\frac{n\pi y}{b}$$

$$S = Q_n\left[\frac{n\pi}{b}\left\{(x+a)\cosh\frac{n\pi}{b}(x-a) + (x-a)\cosh\frac{n\pi}{b}(x+a)\right\} + \sinh\frac{n\pi}{b}(x-a) + \sinh\frac{n\pi}{b}(x+a)\right]\sin\frac{n\pi y}{b}$$

If n is an integer $S = 0$, when $y = \pm b$, and $R_x = 0$, when $x = \pm a$

$$\begin{cases} R_y = (-1)^n Q_n\left[\dfrac{n\pi}{b}\left\{(x+a)\sinh\dfrac{n\pi}{b}(x-a) + (x-a)\sinh\dfrac{n\pi}{b}(x+a)\right\} + 2\cosh\dfrac{n\pi}{b}(x-a) + 2\cosh\dfrac{n\pi}{b}(x+a)\right] \text{ along the edges } y = \pm b. \\ S = Q_n\left[\dfrac{2n\pi a}{b} + \sinh\dfrac{2n\pi a}{b}\right]\sin\dfrac{n\pi y}{b} \end{cases}$$

at $x = a$, the sign of s being changed at $x = -a$

give a series of pairs of functions for R_y and S at the boundaries. These will be termed the Q functions.

The application of the foregoing method will now be illustrated by taking the following case :—

A square plate bounded by the sides $x = \pm a$, $y = \pm a$ is subjected to an approximately sinusoidal distribution of R_y along the edges $y = \pm a$, the sides $x = \pm a$ being free from stress. This problem has some practical interest in revealing how far this unevenly distributed pull tends to become uniform by the time the centre line of the plate $y = o$ has been reached, and also to what extent tranverse stresses are developed. By putting $b = a$ in the general expressions just evaluated, the following five pairs of values for R_y and S at their respective boundaries can be obtained :—

By taking the coefficients P_0, P_2, Q_1, Q_2, Q_3 in the ratios $\frac{26}{25} : -\frac{1}{20} : \frac{1}{7} : \frac{1}{50} : -\frac{1}{3000}$, and superposing a constant value of R_y to make R_y zero at $x = \pm a$, an approximately sinusoidal distribution of R_y is obtained along the edges $y = \pm a$, and the value of S along the sides $x = \pm a$ is eliminated to such an extent, that only a small undulation remains, the maximum of this undulation being less than a half per cent. of the mean value of R_y.

The distributions of R_y at the levels $y = \pm a$, $y = \pm \frac{a}{2}$, $y = o$ are shown by Fig. 1, and it will be observed that there is a marked tendency for this distribution to become uniform, but the plate being square the distance is not sufficient to permit of anything like uniformity being attained by the time the centre line is reached.

The distribution of transverse stress R_x across the lines $x = o$, $x = \pm \frac{a}{2}$, $x = \pm a$ are given to the same scale by Fig. 2. Fig. 3, drawn to twenty times this vertical scale, indicates the distribution of the residuary shear stress which remains in the sides $x = \pm a$.

The methods outlined in the foregoing communication, although they call for considerable labour and arithmetical accuracy, provide a direct and powerful method of attack. Given sufficient perseverance, any problem in which the distributions of stress applied to the boundaries, or the displacements of these boundaries, are known, can be investigated. The method has been applied with success to cases other than the comparatively simple one outlined in this communication, and by employing curvilinear co-ordinates the treatment can be extended to deal with a plate having curved boundaries.

In conclusion, the author would like to put on record the valuable assistance received from Mr. L. Patrick, B.A., scholar of Queen's College, Cambridge, in carrying out the arithmetical computations.

THE TINPLATE MARKET.—The Royal Metal Exchange, Swansea, reports that the slight improvement in the inquiry for tinplates is maintained, but the prices at which orders have been taken do not cover the present cost of manufacture. More mills have, however, been started, and hopes are entertained that these may continue working for some time. Swansea Harbour Trust returns show that during the week ended September 17, 58,226 boxes were received from the works, as compared with 69,271 for the previous week, and 62,608 for the corresponding week of last year. The week's shipments amounted to 49,899 boxes, and the stock at the docks on September 17 was 137,840 boxes.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

GAS ENGINES, PRODUCERS, HOLDERS, &c.

165,906. C. G. Pullin, Isleworth, and S. L. Groom, Streatham, London. Internal-Combustion Engines. (4 *Figs.*) March 3, 1920.—The principal object of the invention is to provide a simple and cheap construction of internal-combustion engine in which the explosive charge undergoes compression in a closed crank case before admission to the cylinder. The invention consists in casting the cylinder 2 and crank case 3 in one and in providing the cylinder with a detachable head 10

Fig. 1.

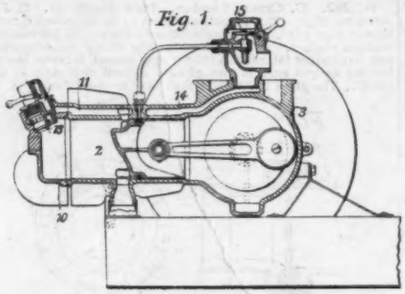
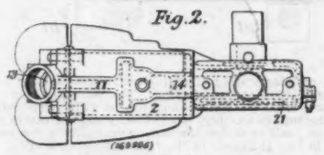


Fig. 2.



and the crank case with one detachable wall 21. The induction passage 14 and the transmission passage 11 are also formed in the wall of the cylinder 2, the passage 14 extending into the wall of the crank case to a port formed to receive a mixture supply valve 15 while the passage 11 is extended in the detachable head 10 to a port 13 for communication with the explosion end of the cylinder for control purposes. (*Accepted July* 20, 1921.)

165,907. C. G. Pullin, Isleworth, and S. L. Groom, Streatham, London. Internal-Combustion Engines. (4 *Figs.*) March 3, 1920.—To obviate the use of separate controls for the fuel and lubricant supplies to internal-combustion engines, a single valve 1 controlling the main air inlet is arranged to control the lubricant delivery pipe 15, and also the flow from

Fig. 1.

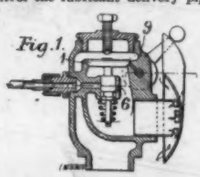
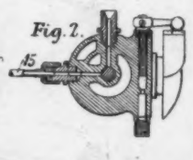


Fig. 2.



the fuel nozzle 9. The fuel nozzle 9 is arranged in the seating of the valve 1 so that on the valve being lifted from its seating, the induced stream of air acts as an ejector stream to the fuel nozzle, and simultaneously, supply of lubricant to the delivery pipe 15 is permitted owing to the displacement of the valve stem 6. (*Accepted July* 20, 1921.)

165,908. C. G. Pullin, Isleworth, and S. Groom, London. Internal-Combustion Engines. (2 *Figs.*) March 3, 1920.—The control of internal-combustion engines is effected, according to this invention, by subjecting only predetermined volumes of the combustible mixture to full compression. The invention consists in controlling the escape of mixture from an internal-combustion engine cylinder by a spring-controlled valve with a wire-drawing passage. The wire-drawing tends to raise the internal pressure in the combustion space and to close the valve on to its seating against the action of the spring when a predetermined pressure, adjustable by the spring, is reached. The cylinder 2 is formed with a transmission passage 11 in its wall connected to both ends of the combustion space; at the lower pressure end by an inlet port 12 and at the high-pressure end by an outlet port 13. The engine works on the two-stroke cycle, the charge being compressed in the closed crank chamber 3 prior to admission to the cylinder 2. The speed of the engine is modified by permitting a portion of the charge admitted to the combustion space to escape through the outlet 13 and back down the transmission passage 11 to the closed crank chamber 3. The control valve is constructed to close automatically when a predetermined pressure in the combustion space is obtained, that is, when the predetermined portion of the charge to be removed has passed through the outlet 13. The control valve 18 is seated in a guide member provided with circumferential openings 21. The guide member is retained in position by a casing 25 which is seated in the wall of the cylinder by an externally-threaded gland member 26. On the valve spindle 19 is a nut member 29, and a compression spring 30 is disposed between the casing 25 and the nut member 29. A sleeve member 31 is disposed on the spindle 19 to limit the movement of the valve spindle impressed by the spring 30 on the nut 29 by reason of its abutting against the nut, and by the provision of a handle 32 projecting through a slot in the wall of the casing. When the full charge in the engine cylinder is to be subjected to compression and ignition, the sleeve 31 is in its outermost position relative to the cylinder and by engagement with the nut 29 retains the valve on its seating. When a predetermined portion of the mixture is desired to be liberated from the compression space, the sleeve member 31 is given a longitudinal displacement within the valve casing 25 by operation of the handle 32. In this position, the valve 18 is maintained off its seating by the pressure of the spring 30, and the opening between the valve

Fig. 1.

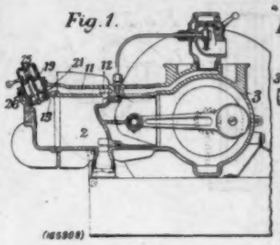
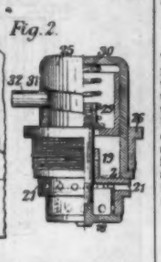


Fig. 2.



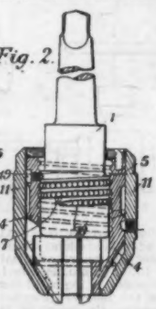
and its seating is regulated by the amount of longitudinal displacement of the sleeve member 31. In this position of the valve, a portion of the mixture commences to flow from the combustion chamber as the engine piston commences its compression stroke, the expelled gases flowing out between the valve 18 and its seating through the circumferential openings 21 to the transmission passage 11. The flow of the gases between the valve and its seating obtains an accelerated velocity as the piston advances until the desired wire-drawing effect is produced, for, as the mixture is unable now to leave the cylinder quickly, the pressure therein immediately rises and overcomes the effective effort of the spring member, whereon the valve closes on to its seating and thereafter the usual cycle of the engine follows. (*Accepted July* 20, 1921.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

165,956. W. T. Brown, Birmingham. Drill Chucks. (7 *Figs.*) April 8, 1920.—According to this invention, anti-friction members (preferably balls) 7, situated between the adjacent faces of the central arbor 1 and the rotary body part 4, 11, engage with helical grooves 5 in each of the members. The balls 7 constitute the operative connection between the arbor and body part. A peg or stop 18 is fitted or formed in the helical groove

Fig. 1.

Fig. 2.

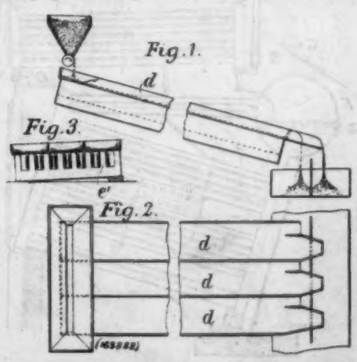


in the central arbor 1 at or near the lower end thereof, and a peg or stop 19 is fitted or formed in the helical groove in the body part at or near the upper end thereof. The stops are arranged to limit the relative movement between the arbor and body part and also prevent the exit of the anti-friction members 7 from the ends of the helical grooves. (*Accepted* July 20, 1921.)

MINING, METALLURGY AND METAL WORKING.

165,822. W. M. Mordey, Westminster. Electro-Magnetic Separation of Minerals. (8 *Figs.*) March 28, 1919. The method of effecting the electro-magnetic separation of minerals consists, according to one way of carrying the invention into practice, in causing a stream of finely-divided mineral material in the form of pulp to flow longitudinally through a relatively long and

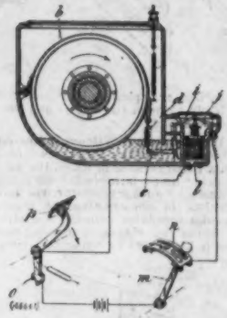
Fig. 1.



narrow inclined launder or trough *d* that may be slightly higher at one side than at the other. The trough *d* is arranged on or over the parallel poles e^1 of an alternating current multiphase electro-magnetic system. The stream of finely-divided mineral material is subjected to the action of the multiphase magnetic field set up by the electro-magnetic system, and material, which is responsive to the action of such a moving magnetic field becomes separated from the gangue or other material present which is not responsive to such field. The responsive material is gradually swept by the magnetic field in a lateral direction to the higher longitudinal side of the trough *d* whilst the inert matter is caused by gravity to move gradually to the opposite or lower longitudinal side of the trough. In this way, the responsive matter and inert matter separated more or less completely from each other, move simultaneously down the trough and are discharged at its lower end into separate receptacles or are otherwise dealt with. The material instead of being in the form of pulp may, in some cases, be in the dry state. The movement of the material may be assisted by imparting a vibrating or jerking motion to the trough, particularly when the material is dry. (*Accepted July* 20, 1921.)

MOTOR ROAD VEHICLES.

165,847. E. J. De Normanville, Cricklewood, London. Transmission Gear. (2 *Figs.*) August 14, 1919.—In motor road vehicles provided with epicyclic gears of the brake-controlled type, the braking action is applied yieldingly and gradually, and the brake brought into action without shock, even if the controlling handle be moved violently, by arranging a spring *d* between the brake band *b* and its operating member *c*. The operating member *c* is moved by toggle arms *i*, *j* or other device adapted to move the member *c* a limited distance and retain it in the position to which it is moved. Preferably the brakes are applied initially to start the braking action by electro-magnetic means controlled by a small lever on the steering wheel or column for making and breaking the electric circuits, though in



the arrangement illustrated, the arms *i*, *j* are moved by an electro-magnet *l* energised by a circuit including a control arm *m* movable in a gate *n*. The arm *m*, when brought to the end of any one of the channels in the gate *n*, closes a circuit including the electro-magnet of one of the brake devices so that any of the brakes, as required to give different velocity ratios, is applied by exerting only so much effort as is required to operate the control arm *m*, and when applied will be maintained in operation by the arms *i*, *j*. A switch *o* operated by a pedal *p* is provided to control all the circuits so that by depressing this pedal all the circuits are broken to liberate the brakes irrespectively of which of them is in operation at the time. For this purpose the circuits through all the electromagnets are brought to one pole of this switch. (*Accepted July* 20, 1921.)

RAILWAYS AND TRAMWAYS.

162,912. The Metropolitan Carriage, Wagon and Finance Company, Limited, Saltley, Birmingham, and E. E. W. Squires, Saltley, Birmingham. Draw Gear. (4 *Figs.*) April 29, 1920.—In draw-bar cradles for railway vehicles in which the end parts are formed separate from the side bars *d*, and the side bars have cranked ends adapted to engage seats *f*

Fig. 1.

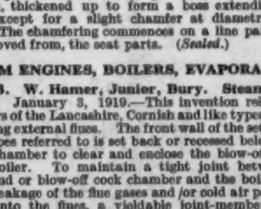
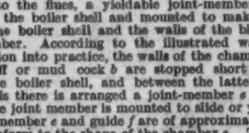


Fig. 2.



in the end discs *e*, and to be riveted therein, the whole of each disc, except the recessed seat portions, is, according to this invention, thickened up to form a boss extending to the periphery, except for a slight chamfer at diametrically opposite points. The chamfering commences on a line parallel with, but well removed from, the seat parts. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

165,463. W. Hamer, Junior, Bury. Steam Generators. (7 *Figs.*) January 3, 1919.—This invention relates to steam generators of the Lancashire, Cornish and like types set in masonry and having external fires. The front wall of the setting for boilers of the types referred to is set back or recessed below the boiler to form a chamber to clear and enclose the blow-off or mud cock of the boiler. To maintain a tight joint between the walls of the mud or blow-off cock chamber and the boiler shell and to prevent leakage of the flue gases and/or cold air passing from the outside into the flues, a yieldable joint-member is shaped to fit against the boiler shell and mounted to make a tight joint between the boiler shell and the walls of the blow-off or mud cock chamber. According to the illustrated way of carrying the invention into practice, the walls of the chamber *c* enclosing the blow-off or mud cock *b* are stopped short of the underside of the boiler shell, and between the latter and the top of the walls there is arranged a joint-member *e* and a guide *f* wherein the joint member is mounted to slide or yield vertically. The joint-member *e* and guide *f* are of approximately U shape in plan to conform to the shape of the chamber *c*. The sides of the joint-member and guide are straight and their ends are curved parallel to the radius of the boiler shell. As shown best in Fig. 3, the guide *f* is of double channel or more or less H section and the joint-member *e* is formed with a tail portion e^1 adapted to enter

and slide in the upper channel of the guide, springs being provided between the tail portion e^1 and the web f^2 of the guide to press the joint-member upwards and against the boiler shell. Preferably the springs are spiral and are mounted on set screws h which pass freely through the web f^2 and are screwed into the tail portion e^1. (*Sealed.*)

Fig. 1.

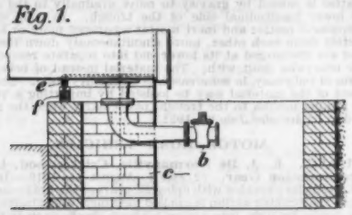


Fig. 2.

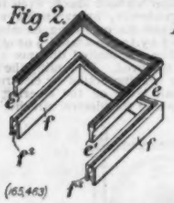
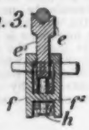


Fig. 3.



(165,463)

165,502. Babcock and Wilcox, Limited, London, and A. Spyer, London. Boiler Furnaces. (7 *Figs.*) February 28, 1920.—In a boiler furnace in which the air is supplied to ash pits for coal firing or to burners for oil firing under pressure through air ducts by an air regulator, the novel feature of the invention consists in constructing the regulator in the form of a bit and miss ventilator with the deflecting vanes attached to the inner side of the stationary member nearest the furnace. The invention is illustrated in connection with a boiler furnace

Fig. 1.

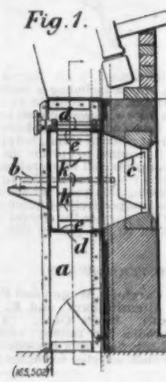
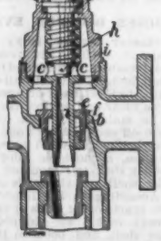


Fig. 2.

(165,502)

fitted for oil firing, a denoting the duct for supplying air under pressure to the furnace, b the oil burner, and c an air mixer consisting of a truncated cone. d is a cylinder mounted to rotate within the duct a and fitting over a cylinder e disposed within the duct a coaxially with the oil burner. The cylinders d, e are each provided with openings f, g, respectively, in their peripheral walls. To one edge of each opening in cylinder e are attached deflecting vanes k in such manner as to cause uniform diffusion of the air inside the cylinder. (*Accepted July* 13, 1921.)

165,958. R. G. Brooke, Macclesfield. Injectors. (5 *Figs.*) April 8, 1920.—A steam-operated injector, in which the steam cone is adapted to be advanced and retracted by rotation of a screw-threaded spindle, has the cone constructed to act as a key for turning the stuffing-box, which action is necessary to screw the latter home, the cone being itself turned by a key before the cap is applied to the injector. The cone a is formed between the portion that slides in the stuffing-box b and ports c



through which steam has access to the cone, with a squared neck any opposite pair of faces of which fit between ledges e formed upon the outer flanged end f of the stuffing-box b so that rotation of the cone can be transmitted to the box. The portion A of the cone beyond the ports c is of square shape externally, and is so proportioned in relation to the body of the injector that when the cap i is removed, it projects sufficiently far to enable a spanner or key to be applied to it for turning purposes. (*Accepted July* 20, 1921.)

165,264. T. H. Parker, West Kensington. Rotary Motors. (4 *Figs.*) April 16, 1920.—The improvements refer to fluid pressure motors of the type wherein pistons are arranged concentrically around and parallel to the shaft and work in cavities formed in a rotor mounted on the shaft. The outer ends of the pistons engage with a cam track so that when pressure is exerted on the inner ends of the pistons they will be caused to run on the track and rotate the rotor and shaft. According to

Fig. 1.

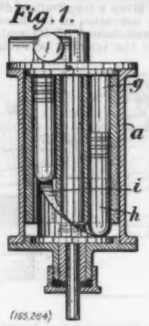
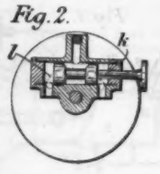


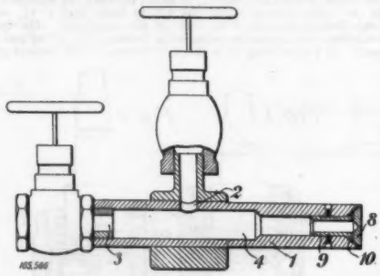
Fig. 2.



(165,264)

this invention, one end of the cylinder a is provided with an inlet port k and an exhaust port l, which ports are so arranged that pressure through the inlet port k is exerted in sequence on the pistons h in the cavities g in the rotor so as to drive them down the cam track i upon which they rise when the cavities in which they are placed come opposite the exhaust port. The inlet and outlet ports may be shaped so as to supply to and exhaust from two cavities simultaneously. (*Sealed.*)

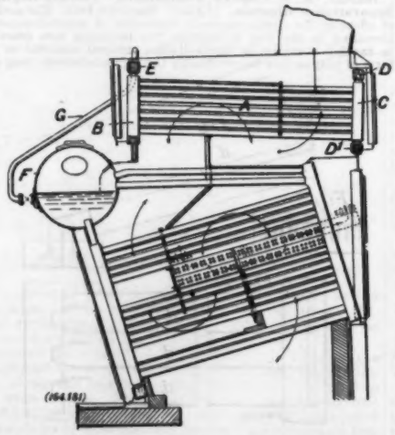
165,566. J. B. Armstrong, North Shields. Oil Fuel Burners. (3 *Figs.*) April 13, 1920.—A liquid fuel burner to give a parallel spray, which may be regulated to any desired length, and to effect more complete combustion of the fuel, comprises a nozzle 1 having the usual oil and compressed air supply inlets 2, 3, respectively, opening into a mixing chamber 4. According to this invention, the outlet end of the nozzle 1 is bevelled or countersunk and fitted with a jet piece comprising a conical head 8 corresponding with the bevel or countersink, and a sleeve



(165,566)

or tubular piece 9 which extends into the nozzle. The conical head 8 is spaced slightly from the nozzle and the mixture of air and oil enters the annular conical space through radial holes or apertures 10. The atomised fuel emerging from the annular conical space creates a region of low pressure in front of the jet piece, so that the flame is drawn inwardly and burns in a parallel spray. To regulate the length of the spray, the jet piece is adjusted axially to vary the annular conical space. (*Accepted July* 13, 1921.)

164,181. Babcock and Wilcox, Limited, London, and W. Innes, Whitley Bay. Steam Generators. (1 *Fig.*) March 24, 1920.—A steam generator of the Babcock and Wilcox type has its feed water heater or economiser located above the generator. The heater or economiser comprises a number of tubes A connected at their ends to a series of headers B and C. The headers C are all joined at the top to a box D, the headers B



(164,181)

being also all joined at the top to a box E. At the lower end of the headers C is a box D^1. An inlet pipe is connected to the box D, into which box D the feed water is pumped, and from which it passes through the tubes A in which it is heated by the waste gates of combustion on their way to the uptake or chimney. The feed water is fed from the box E, by way of a pipe G, to the steam drum F. (*Sealed.*)

MISCELLANEOUS.

165,293. G. T. F. Royle, Longsight, Manchester, and J. Dailey, Shawheath, Stockport. Pneumatic Pipe Couplings. (4 *Figs.*) May 13, 1920.—A coupling for flexible pipes conveying compressed air comprises a coupling piece c inserted within the pipe a, a split ring e on the outside of the pipe a and a nut g threading on to the coupling piece and engaging the split ring. The characteristic feature of the invention consists in forming the split ring e with a diagonal or spiral groove f. When the nut g is tightened, the split ring e is compressed and the groove f is wholly or partially closed upon the pipe a, so that there is no point in the pipe a at which air can escape in a direct line as would be the case if the groove f were parallel with the axis of the sleeve e. (*Sealed.*)

Fig. 1.

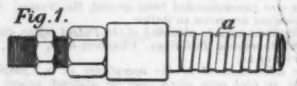


Fig. 3.

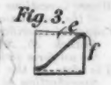


Fig. 2.

Fig. 4.

(165,293)

165,262. G. Green, London. Pipe Junctions. (2 *Figs.*) April 14, 1920.—This invention relates to an improved construction of pipe joint, particularly intended for use on internal combustion engines. A cheap and flexible clamp for compressing and expanding laterally a rubber ring placed between the contacting flanged ends of two pipes is formed of a strip of sheet metal. The pipes 1, 2 to be joined have recessed flanges 12, 4 to

Fig. 1.

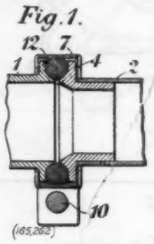
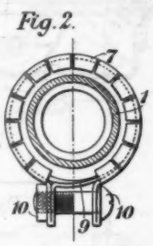


Fig. 2.



(165,262)

provide an annular seating of semi-circular cross section for a rubber ring of circular cross-section. The clamping ring consists of a strip of copper 7 of channel section with nicked edges, which, at the ends of the strip, are cut away and the centre part bent back on itself to stiffen the end. One extreme free end 9 is bent again into the circle of the ring and engages within the opposite channel end, as appears in Fig. 2. The stiff doubled ends are drawn together by a set screw and nut 10. (*Sealed.*)

165,655. The Skinningrove Iron Company, Limited, Saltburn-by-the-Sea, and T. R. Smith, Saltburn-by-the Sea. Depositing Dust from Gases. (2 *Figs.*) June 21, 1920.—The object of this invention is to improve the construction of the electrode employed in electrostatic plant used for the deposition of dust and particles from gases. According to the invention, the negative electrode is formed as a curtain of chain

Fig. 2.

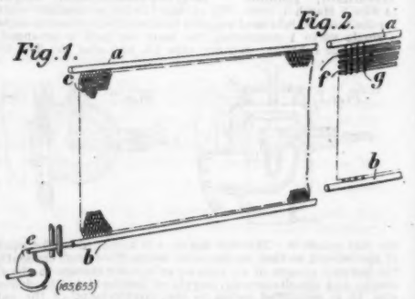
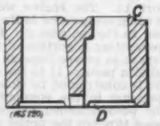


Fig. 1.

(165,655)

mail c, Fig. 1, or, according to a modification, of a series of longitudinal metal bars f supported by interlacing wires g. The electrode is supported at its top edge by a bar a with a heavy bar b attached to the bottom edge. The heavy bar b is raised and dropped at intervals by means of a cam e to produce a violent jarring of the electrode which also sets it in vibration. By this means, a more effective cleaning of the meshes is obtained. (*Sealed.*)

165,120. W. Bagguley, Nottingham, and R. Hickton, Nottingham. Bricks. (6 *Figs.*) September 10, 1920.—Hollow bricks or blocks for use in the construction of chimneys, flues and other shafts have on one side two square projections C, and on the opposite side cavities D of similar shape. The sides



(165,120)

of the projections and cavities are at an angle of about 30 deg to the vertical. In building, the projections on the bricks on one tier or layer engage the cavities in the bricks on the tier or layer above. The several tiers or layers are thus locked together. (*Sealed.*)